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Prevalence and implementation of small-sided games in rugby union: a preliminary survey study

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ABSTRACT
Small-sided games (SSG) are popular in team sports training because they are thought to promote physiological, kinematic, and tactical benefits. Researchers in the football codes often use this as a rationale for conducting SSG-related investigations. However, the prevalence of SSG has not been scientifically documented in rugby union (RU). Therefore, the purpose of this study was to examine the prevalence of SSG in RU and develop understanding of how SSG are implemented in RU practice. An anonymous, multiple-choice electronic survey including a proposed consensus definition was dispersed globally through email and several social media platforms. The survey was launched and re-distributed six times at regular intervals over a one-year period. One hundred and fifteen responses were collected from various RU coaching strata. The respondents ratified the proposed definition, identifying SSG as modifiable methods representative of the full game, which can be used to target various training outcomes. Ninety-nine percent of survey participants used SSG. The largest cohort was characterised by ≥5 years of coaching experience (n = 76; 66% of sample) in New Zealand (n = 89; 77%), fulfilling the role of head coach (n = 61; 53%) to male RU players (n = 79; 69%). Eighty-five percent of coaches (n = 98; 85%) reported using SSG every 1 to 3 sessions. 3v3 (top 1) and 5v5 (top 3) were the most popular formats. These formats were used to improve technique (n = 30; 26%) and promote fun (n = 29; 25%). SSG are widespread and frequently used by New Zealand RU coaches through involving different numbers of players. RU staff have a uniform conceptual understanding of SSG. The implementation of SSG is related to coaching roles. Meaningful differences in the implementation of SSG are plausible in RU practice depending on playing levels, coaching experience, player sex, and geographic location.

1. Introduction

Small-sided games (SSG) are modified versions of team sports, or non team sport-specific games, lauded and prescribed for their potential to concurrently enhance physiological, technical, tactical, as well as social qualities in a sport-specific manner (Aguiar et al., 2012; Davids et al., 2013; Fernández-Espínola et al., 2020; Gabbett et al., 2009a; Hammami et al., 2017; Kinnerk et al., 2018). Interest in SSG has increased in the last two decades as evidenced by the body of research examining SSG for general use and in specific sports. Rugby union (RU), however, remains understudied in this research area (Aguiar et al., 2012; Bujalance-Moreno et al., 2018; Fernández-Espínola et al., 2020; Gabbett et al., 2009b; Halouani et al., 2014; Hammami et al., 2018; Harrison et al., 2015; Hill-Haas et al., 2011; Impellizzeri et al., 2006; Kinnerk et al., 2018; Sarmento et al., 2018).

Researchers in a variety of sports, including basketball, lacrosse, handball, Gaelic football, volleyball, soccer, and RU and league have consistently alluded to the popularity of SSG in training practice. This notion of common practice-based use has

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in fact generally served as a prelude to the scientific rationale for examining SSG outcomes (Abrantes et al., 2012; Belka et al., 2017; Conte et al., 2017; Gabbett, 2008; Gabbett et al., 2010; Hauer et al., 2018; Mangan et al., 2019; Weakley et al., 2019). The evidence shows that SSG generally improve various fitness, skill, and tactical markers (Hammami et al., 2017; Kinnerk et al., 2018). Yet the quantitative data available is not definitive on all accounts (Kinnerk et al., 2018), nor do SSG replicate match intensities in all contexts (Tee et al., 2016). Incorporating the specific performance context might mitigate the documented discrepancy between training and match demands (Campbell et al., 2018; Hartwig et al., 2011; Tee et al., 2016) in the pursuit of planned success (Tee et al., 2018).

RU is a highly demanding, physical, tactical, and skill-based team sport, which taxes all energy systems and requires a complete and position-specific movement arsenal (Deutsch et al., 2007; Duthie et al., 2003; Hogarth et al., 2016; McLean, 1992). Rugby competition is characterised by long-duration games (80 minutes), consisting of repeated intermittent bouts of short-duration high-intensity effort, interspersed with longer periods at lower intensity (Austin et al., 2011; Hogarth et al., 2016). The specific game demands consist of a multitude of activities including running, passing, tackling, mauling, kicking, jumping, and scrummaging (Deutsch et al., 2007).

The body of knowledge regarding rugby union SSG (SSG^{RU}) is still in its infancy, with only a limited number of studies focusing on the RU-specific population. Within this specific performance-context, the efficacy of SSG^{RU}, their design and constraint-factors, and the influence of player characteristics and feedback on internal and external loading, have been investigated (Chadwick et al., 2019; Gamble, 2004; Kennett et al., 2012; Taylor et al., 2020; Tee et al., 2016; Vaz et al., 2015; Vaz et al., 2016; Vaz et al., 2012; Weakley et al., 2019). The scarcity and heterogeneity of these studies severely limits inferences about the RU population regarding SSG. The presupposition of widespread use, as a scientific rationale, is in line with that of other team sports. However, here too, scant evidence of SSG^{RU} prevalence, or details of its usage in RU training practice are in fact available (Hogarth et al., 2016; Zanin et al., 2021). Moreover, Thomas and colleagues (2013) have shown that the on-field application of effective game-based training can be more challenging than the literature suggests; the inclusion of these training methods into practitioners' arsenals might not be self-evident. Thomas et al. (2013) suggest anchoring SSG into coaches' education through peer-based support, to ensure effective implementation (Thomas et al., 2013).

Despite the potential application of SSG to specific performance contexts, and the claims made about the widespread use of SSG in RU, the lack of evidence regarding its actual practice-based prevalence and implementation impinge on an evaluation of SSG^{RU} real-world efficacy. Clearly, evidence-based, effective application of SSG could provide important technical, tactical, and physical benefits, within specific performance contexts in RU. The purpose of this study was therefore to establish an understanding of the actual current application of these training forms to RU practice, and to identify differentiating factors within its implementation, as well as potential asynchrony with the literature. In so doing, optimisation can be sought for the application of SSG^{RU}, relative to their specific performance contexts.

2. Methods

This study entails descriptive research regarding the prevalence and implementation of SSG within the population of RU practitioners through stratification of the sample (n = 115) into various cohorts (Table 3). To this end, a questionnaire was developed according to methodological good-practice procedures for the development of surveys (e-survey), provided by Portney and Watkins (2009), as outlined below (Portney & Watkins, 2009).

2.1. Developmental procedure

The delineation of the research question was addressed by drafting six guiding questions to help direct the setup of the investigation (Table 1). These guiding questions were complemented by six hypotheses (Table 2), capturing the expected study outcome(s). The translation to a questionnaire outline was bound to the options available in the Qualtrics Online Survey Software (Qualtrics, 2019). Portney and Watkins (2009) was consulted regarding the identification and selection process of instruments (Portney & Watkins, 2009).

Qualtrics Survey Software was selected for methodological convenience and global reach. The design of the instrument was guided by the Qualtrics software workflow (Qualtrics, 2019). All preliminary drafts were presented to all co-authors for review and adjustments were made through discussion. Upon consensus, the pilot survey was presented to six peers, i.e., sport science researchers and coaches involved in RU, for testing and revisions. Feedback was incorporated to finalise the e-survey.

Table 1: Guiding questions for formalising the research question

Guiding questions
1. How widely spread is the use of SSG in RU training practice?
2. What are SSG^{RU} generally used for in RU training practice?
3. How frequently are SSG used in RU training practice?
4. Which SSG^{RU} formats are most popular?
5. What are the specific conditioning goals SSG^{RU} are used for in training practice?
6. Is there a relationship between RU coaching characteristics and the interpretation and implementation of SSG^{RU}?

Table 2: Research question hypotheses

Hypotheses
1. SSG are used on every level in RU training practice.
2. SSG are used for multiple reasons, including match-specific conditioning, game skills development and fun experience/ motivation.
3. SSG are used more frequently with rising playing level.
4. Mid-range SSG (5v5 – 9v9) are most frequently used.
5. Match-specific aerobic conditioning is the main conditioning goal when applying SSG in RU training practice.
6. Implementation and interpretation of SSG in RU will be dependent on coaches' characteristics.

The final survey consisted of 24 multiple-choice questions, in which click-to-select for pre-formulated absolute or categorical options, drag-and-drop for top-x choice, sliding scale formats for percentages, and "Other" input boxes were provided, adhering to best-practice survey methodology (Portney & Watkins, 2009); ease of use (PC/smartphone), visual appeal, duration, and a uniform, yet non-identical ranking (randomisation) of available responses were built in. Multiple replies were possible for selected questions (e.g., top 5). The survey structure aimed at creating flow by first addressing simpler, participant-differentiating information, systematically followed by more topic-specific questions. Informed consent was integrated, and ethical approval was obtained through an institutional ethics committee (HREC[Health]2019#15). The survey concluded with an optional declaration of additional information.

2.2. Dispersion

RU coaching staff were selected as the target population, i.e., practitioners involved in the delivery of training to RU players. Initial dispersion was done on 07/08/2019, through email lists and social media (Facebook, Twitter, and LinkedIn) available from region coaches and staff involved in RU across a broad range of coaching levels. In addition, RU governing bodies, individual clubs, universities, and schools were randomly targeted via email in New Zealand, Australia, Argentina, South Africa, United Kingdom, mainland Europe, and Japan. These emails were re-distributed six times on a regular basis over the course of one year.

2.3. Analysis

Qualtrics Online Software was used for data processing. Primary results were reported descriptively, based on a selection of outputs; absolute total (participants or choice) counts, and percentages of total survey sample size or relative to substrata. Mean ± SD were reported where appropriate. To identify any statistically significant relationships ($p \leq 0.05$), crosstabs were formed, and Pearson's Chi-squared test (Chi^2) was run and reported with degrees of freedom (D_f). Cramér's V Effect Size [ES] was included for practical interpretation of the results. A 95% confidence interval (CI) was also reported for within category-comparison using the Wilson Score interval. For further analysis, including top one, two, and three sum choice count, and graphical outputs, data were exported to a Microsoft Excel 2016 spreadsheet.

3. Results

3.1. Definition

The definition provided to the survey participants in order to establish an integral baseline understanding, referred to SSG^{RU} as: *"Any modified version of the full game of rugby (15 v 15), whereby through alteration of design variables like player number, playing area, time, and rules, a specific training outcome is pursued. The games should still be identifiable as rugby-related (rugby ball, contact, basic plays)."* All but one survey respondent (99%) agreed entirely with this definition. A single coach (1%) agreed with the definition but felt that it needed to include reference to the "constraints-based" approach and "ecological dynamics".

3.2. Sample characteristics

One test case and 115 responses (n = 115) were collected over a twelve-month period. Ninety-five respondents were still actively coaching. Eleven respondents coached on the international level, 7 professionally (e.g., Super Rugby, Pro14), 19 at national level, 34 locally, and 44 coached school teams. Of these respondents, 61 participants identified as head coach, 24 as strength and conditioning coaches, 19 as assistant coaches, and 2 as sport scientists. Nine identified as "other", including a combination role, director of rugby, and school rugby coach. Mean coaching experience was 4.0 ± 1.2 years. Respondents had predominantly been active in New Zealand and Europe. A minority had coached in North and South America, Africa, Australia, or Asia. No responses were received from the Pacific islands (PI). One respondent coached on several continents. The sample distributions regarding coaching level and role, experience, location, and age-based target group are reported in Table 3. Seventy-nine respondents coached male rugby union players (69%), whereas five coached female players (4%). The remaining 31 respondents coached both sexes (27%).

3.3. SSG prevalence

No statistically significant relationships were found between frequency of SSG implementation in RU and playing level, coaching experience, player sex, or geographical location. Nor were any of the player age categories statistically significantly related to SSG frequency. There was however a strong relationship with staff role (Table 4). Eighty-five percent of

Table 3: Distribution of respondents by strata characteristics (n)

Coaching level	**International** 11		**Professional** 7		**National** 19		**Local** 34		**School** 44
Coaching position	**Head coach** 61		**Assistant** 19		**S&C** 24		**Scientist** 2		**Other** 9
Experience (years)	**<1** 2		**1-3** 16		**3-5** 21		**5-10** 22		**>10** 54
Geographic location	**NZ** 89	**Aus** 2	**Eur** 13	**Asia** 1	**Afr** 3	**SA** 1	**NA** 5	**PI** 0	**Multiple** 1
Age target group	**U6** 7#	**U8** 12#	**U10** 22#	**U12** 32#	**U14** 25#	**U16** 21#	**U18** 39#	**U21** 19#	**Seniors** 39#

Note: S&C = Strength and Conditioning coach; NZ = New Zealand; Aus = Australia; Eur = Europe; Afr = Africa; SA = South America; NA = North America; PI = Pacific islands; U(x) = Under (age group); # Of total 'choice count' (n = 216): multiple categories optional.

respondents (n = 97) reported using SSG regularly to very often, i.e., every one to three sessions. Only one school-level coach reported to be a non-user; thus, 99% of respondents reported using SSG in RU (Figure 1). Most international coaches (55%) used SSG every two to three sessions. Of the professional coaches, equal numbers (43%) used SSG every session and every two to three sessions. Forty-two and 47% of national-level coaches reported use of SSG every session and every two to three training sessions, respectively. The majority (71%) of local practitioners used SSG every session. School rugby coaches mostly used these training forms every session (41%), or every two to three sessions (41%) (Figure 3). With 44% (CI [31-57%]), local-level coaches were significantly overrepresented within the cohort of most frequent SSG users, whereas they were underrepresented with 14% (CI [7-28%]), in regular SSG use ($p \leq 0.01$).

Stratification by coaching experience for frequency of SSG implementation shows a practically meaningful ES (Table 4), indicating nuance between categories (Figure 4). Fifty-six percent of coaches with more than ten years of experience applied SSG every session, most often. In contrast, inexperienced coaches did not use SSG every session. Rather, they were inclined to a more moderate use. Often and regular SSG use thereafter rises with mounting experience, to 83% by ten years of experience. These most experienced coaches are statistically underrepresented (9% [CI: 2-38%]) for moderate frequency SSG use (≥1/5 sessions) ($p \leq 0.01$), whilst those with 3 to 5 years of experience have significantly higher values (46% [CI: 21-72%]) than typical within this frequency category ($p \leq 0.05$).

Differences are evident between specific staff; 61% [CI: 48-72%] of head coaches applied SSG every single session, which is significantly more often than coaches in other roles ($p \leq 0.01$). Consequently, head coaches form 67% of the total amount of very frequent SSG users. This is compensated by an atypical low proportion of head coaches (28% [CI: 18-40%]) using SSG "regularly" ($p \leq 0.05$). The opposite was observed with strength and conditioning coaches [CI: 43-79%], 63% of which implemented SSG at least once per three training sessions, which is more than typical ($p \leq 0.01$). However, an atypically low value of 21% [CI: 9-41%] was found for every session-use ($p \leq 0.01$) within this role. Forty-two percent of assistant coaches used SSG training "very often" and 42% used it "regularly" [CI: 23-64%].

Table 4: Relationship between population sample characteristics and SSG prevalence

		Chi^2	D_f	*p*	[ES]	
Playing level		21.00	16	0.179	0.214	Medium
Coaching experience		21.60	16	0.157	0.217	Medium
Staff role		49.00	16	<0.001*	0.326	Large
Player sex		7.57	8	0.477	0.181	Medium
Geographical location		23.60	28	0.700	0.227	Medium
Player age	**U6**	0.89	4	0.926	0.088	Small
	U8	1.18	4	0.881	0.101	Small
	U10	7.17	4	0.127	0.250	Medium
	U12	1.99	4	0.737	0.132	Small
	U14	5.31	4	0.257	0.215	Medium
	U16	5.10	4	0.277	0.221	Medium
	U18	1.94	4	0.747	0.130	Small
	U21	3.60	4	0.463	0.177	Medium
	Seniors	1.41	4	0.843	0.111	Small

Note: *statistically significant relationship

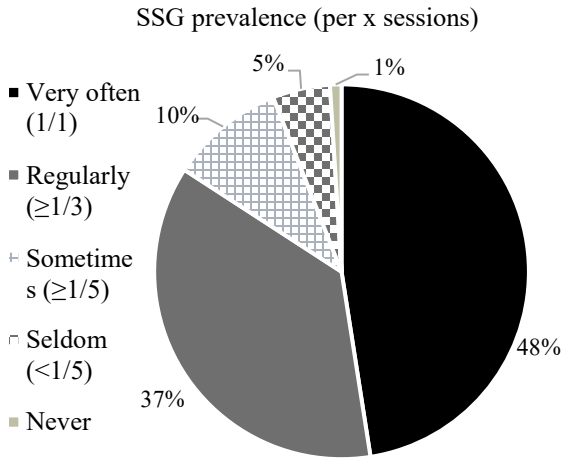

Figure 1: SSG prevalence (% respondents)

SSG formats were applied to all athlete age groups. One to two-thirds of coaches used SSG every training session within their respective target age group (Figure 5). Statistically different values were only seen in U10 coaches, who demonstrated disproportionately higher values for "seldom", and lower values for "regular" SSG implementation than expected ($p \leq 0.05$). The lowest proportion of very often-users (36%) was found for U14 coaches. SSG usage every one to three sessions seemed to fall from U10 to U14 (≤81%), when compared to 83 to 95% of coaches in other age categories. U21 coaches (95%) had the highest proportion of prevalent SSG users. In contrast, U10 and U14 (14% and 12%) coaches were most prone to never or barely apply SSG in training practice.

Practically meaningful distributional differences were noted for SSG implementation to players of different sexes (Table 4); 91% of respondents who worked with both male and female athletes implemented SSG at least once per three training sessions. In comparison, 84% of the cohort exclusively coaching males, and 60% of those solely coaching females used SSG "very often" or "regularly".

No statistically significant differences were found for SSG prevalence in relation to geographic location. The following practical prevalence-ranking for SSG application ("very often" and "regular", respectively) was observed for coaches active in; Africa (67% and 33%), Europe (54% and 46%), New Zealand (47% and 36%), North America (60% and 20%), and Australia (50% both). One survey participant active on several continents, and one in Asia, reported using SSG every two to three training sessions. Two of four coaches active in Australia, and two in South America declared having used SSG once every five sessions only.

3.4. SSG Application

The application of game-based training, in general, served multiple purposes according to RU staff (Figure 2). To pursue these aims using a single format, 3 v 3 was elected most frequently. Further in-depth questioning of participants showed 5 v 5, 3 v 3, and 7 v 7, in that order, to be preferred, when allowing for a top-three choice. Skill development, general aerobic and specific match conditioning were identified training goals of SSG. In addition, 1 v 1 was most preferred in terms of skill development, whilst 10 v 10 was applied almost equally for general aerobic, specific match conditioning, and skill improvement. A detailed view on all game formats is available in Appendix 1.

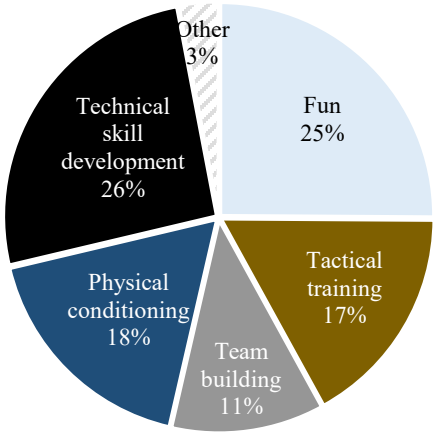

Figure 2: SSG training purpose in RU (% respondents)

4. Discussion

The widespread use of SSG in RU practice is an accepted notion amongst researchers, whilst SSG^{RU}-related research remains scarce. The evidence for this notion seems solely grounded in anecdote, at best referencing prior studies with similar statements. This study verifies these claims for the first time and maps out the practical application of SSG. The authors put forward, for the first time, a comprehensive RU-specific definition for SSG, which was virtually unanimously ratified by all participants.

Information was collected from coaches representing every level of play. Within the collected sample, school and local coaches accounted for over half the survey responses. This majority exemplifies the truism that more coaches are active on the lower levels of RU, as it is self-evident that more amateur than professional players participate throughout societal strata (World Rugby, 2020). The survey sample also shows RU staff are active worldwide, in line with RU's global impact (World Rugby, 2020, 2021). A disproportionate return of survey responses from New Zealand, and in the second instance European-based coaches, might reflect geographical differences. This perceived imbalance might be symptomatic of the smaller role RU plays in other parts of the world, relative to other sports (*Biggest Global Sports: A statistics-based analysis of the world's most popular sports* 2021; TOTALSPORTEK.COM, 2021). Absolute population, socio-economic factors, and absolute numbers of participation (e.g., Pacific Island nations) could also play a role in the selective survey return. In contrast, when looking at the delivery across targeted age groups, coaching staff were more evenly distributed.

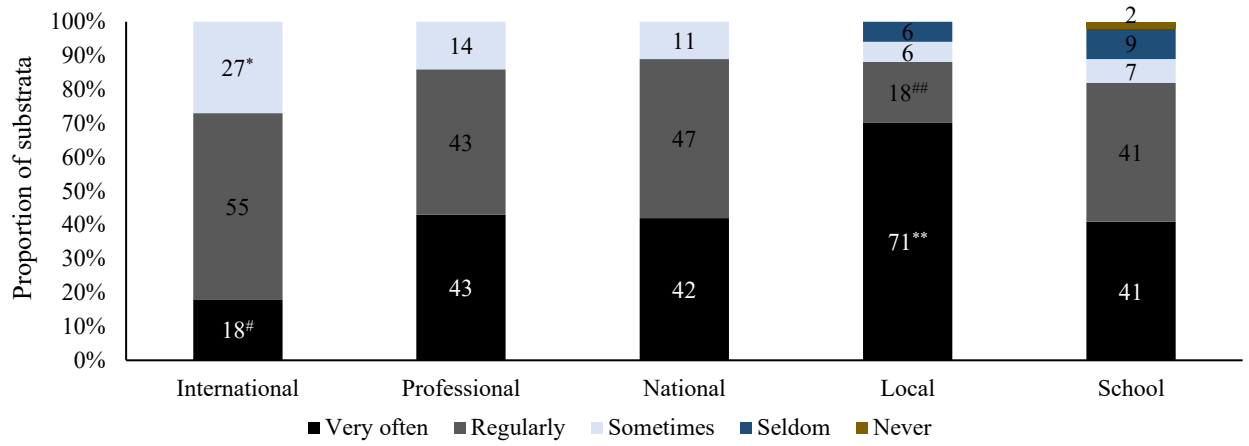

Figure 3: Playing level-dependent SSG use (% of substrata); significantly higher (*/**), lower (#/##) than typical ($p \leq 0.05$ / $p \leq 0.01$)

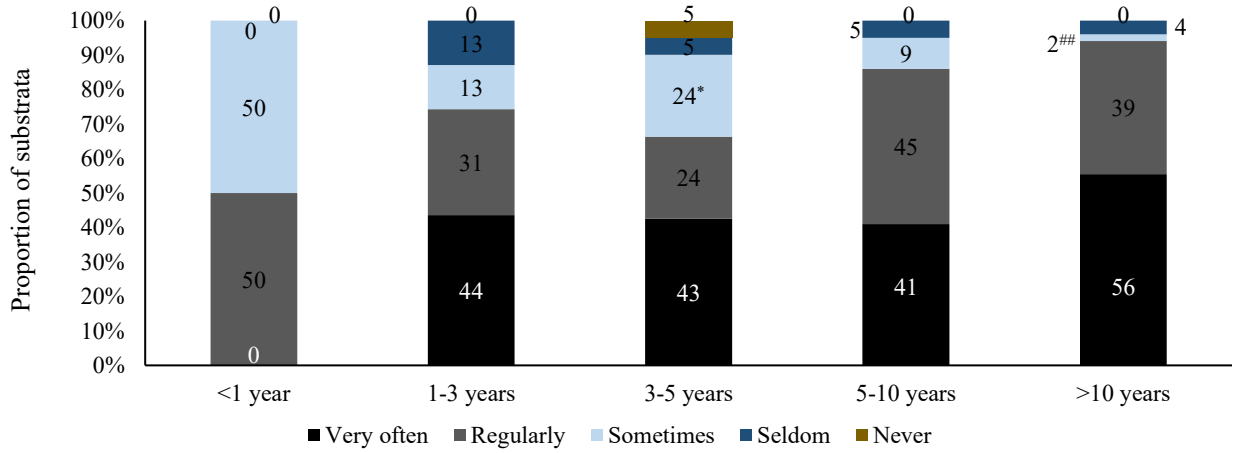

Figure 4: Coaching experience-dependent SSG use; significantly higher (*/**), lower (#/##) than typical ($p \leq 0.05$ / $p \leq 0.01$)

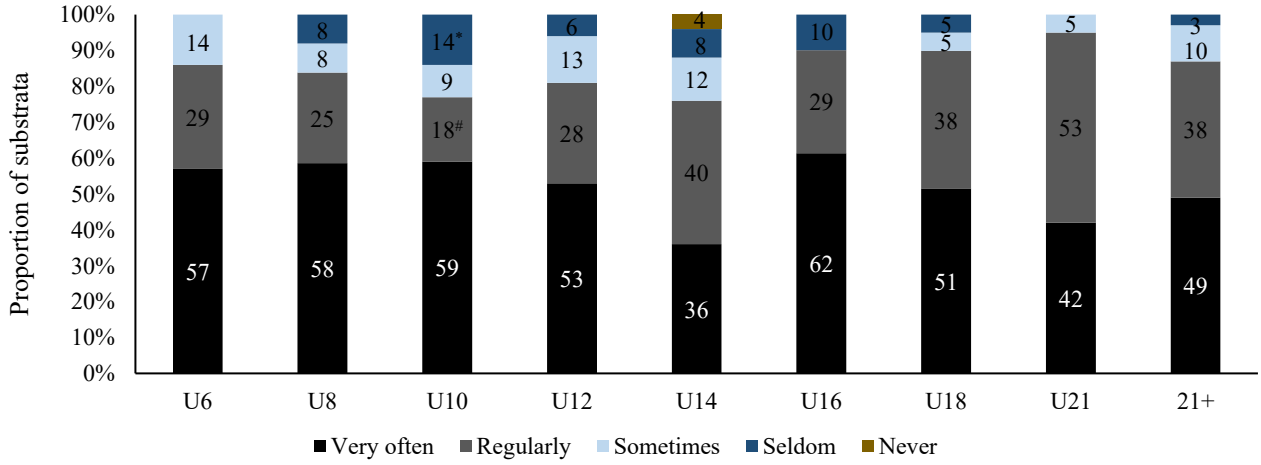

Figure 5: Age group-specific SSG use (% of substrata); significantly higher (*/**), lower (#/##) than typical ($p \leq 0.05$ / $p \leq 0.01$)

The results show SSG^{RU} are an every session staple for almost half the respondents. Only a small minority of practitioners (6%) implemented these training forms infrequently. Despite there being no clear relationship, RU coaches seem to favour the use of SSG increasingly throughout their careers; more experienced coaches implement this method more often. This observation is consistent with the notion that novice coaches take time to grow into the use of SSG (Kinnerk et al., 2018). A mentorship-approach has consequently been proposed to optimise the integration of game-based training methods in starting coaches (Kinnerk et al., 2018). As staff role strongly relates to SSG prevalence, it is of note that head coaches reported the highest amount of every session SSG use (61%), compared to other roles. This was also seen for practitioners operating on the local level (71%). As such, local-level and head coaches are the cohorts with the highest proportion of most frequent SSG use, within playing level and role-based stratification (44 and 67%, respectively).

The proclivity of head coaches to use SSG more frequently might be related to a larger array of responsibilities compared to other staff, thus selecting a more generalised and game-minded approach. The level-dependency is hypothesised to be due to necessity, belief favouring potential efficiency, and motivational efficacy with amateur players. Additionally, on the local level, rugby staff specialisation would be less likely. Aside from locally operating coaches, and based on slightly lower frequency (i.e., minimally once per three sessions), SSG prevalence was similar across all levels. Regardless of player age, SSG were most often implemented every training session. A slight drop in sessional SSG-application with older players might indicate more practice is directed towards compartmentalised and specialised drills. In contrast, 'fun experience' might be emphasised more in youth RU. The higher degree of frequent SSG usage observed in coaches working with both sexes and males as compared to female players exclusively, is noteworthy. Practically meaningful differences might exist. More evidence is needed to establish potential statistical differences.

Coaches indicated that this game-based training methodology is important to them for pursuing technical development and fun-experiences, especially. Player motivation and enjoyment has been found to be superior when employing SSG (Kinnerk et al., 2018). Greater engagement might consequently lead to better training outcomes. These training outcomes were identified to be differentially related to specific game formats (Appendix 1); the larger the game format, the more it was used for general and match-specific conditioning, whereas smaller game formats were employed for technical development. In view of the importance of the anaerobic component in rugby performance, practitioners need to consider repeated high-intensity efforts (Austin et al., 2011; Duthie et al., 2003). To that end, coaches used large-sided games (LSG) less than SSG to target repeated sprint ability. It is furthermore remarkable that no specific format was reserved for recovery purposes. In general, the variety of SSG^{RU} formats implemented seems to centre around 3-, 5-, and 7-a-side, complemented by individual settings (1 v 1) and LSG (10 v 10). The data cumulatively shows certain trends exist in training practice, and indicate that among RU coaches, SSG are perceived as multi-purposeful, in accordance with the literature (Bujalance-Moreno et al., 2019; Davids & Araújo, 2010; Davids et al., 2013; Davids et al., 2012; Fernández-Espínola et al., 2020; Ford et al., 2009; Gabbett et al., 2009a; Hammami et al., 2017; Harrison et al., 2015; Hoff et al., 2002; Kinnerk et al., 2018; Kirk & MacPhail, 2002; Ward et al., 2007). Increases in technical skill and fun seem to be targeted primarily by coaches.

This survey identified a wide range of participants. The collected demographics allowed for the classification into a variety of substrata, within which specific emphasis exist for SSG implementation. Experienced New Zealand-based head coaches were the most prevalent. Game-based training was predominantly used to improve technical skill and fun, and applied most commonly with (young) adult male RU players. This study provides evidence indicating that SSG^{RU} are used frequently in New Zealand and likely in Europe. The results show that game-based training is prevalent throughout the developmental pathway, on all levels of play. Therefore, we can affirm the plausible and frequent claims in the football codes literature, that to date have been anecdotal and empirically practice-based, yet scientifically unsubstantiated (Abrantes et al., 2012; Aguiar et al., 2013; Dellal et al., 2011; Fleay et al., 2018; Mangan et al., 2019; Owen et al., 2012; Vaz et al., 2016). Considering the surge in research regarding SSG in the football codes (Bujalance-Moreno et al., 2019; Fernández-Espínola et al., 2020; Hammami et al., 2017; Hill-Haas et al., 2011; Reilly & Gilbourne, 2003; Sarmento et al., 2018), a factual perspective on practice-based SSG^{RU} usage is indispensable. To our knowledge, this survey is the first to quantify SSG prevalence in RU.

5. Conclusion

This study identified the use of SSG by rugby union practitioners. To the authors' knowledge, this is the first survey investigating the application of SSG in rugby union training practice. Rugby union staff agreed with the proposed definition of SSG and provided evidence of its use. SSG are prevalent throughout age groups and playing levels in New Zealand rugby union. The use of SSG with various target groups is differentiated by practitioners' characteristics. SSG implementation is dependent on staff role and practically meaningful differences might exist for playing levels, coaching experience, player sex, and geographic location; head coaches and coaches in local competitions implement SSG most frequently. Skill enhancement and enjoyment are important reasons for which practitioners apply SSG, which commonly incorporate between three to seven players a side. To optimise rugby union training, a larger body of evidence is required for establishing a more definitive evidence-based perspective on the existing differences in SSG application.

6. Key points

Point 1 – RU coaches interpret SSG similarly and are adherent to RU-specificity when implementing SSG.

Point 2 – SSG are used across all levels of play and age groups in RU-practice.

Point 3 – Skill and fun are important drivers for the use of SSG and differences in SSG-implementation are cohort-dependent.

7. Limitations

Despite extensive exposure through several electronic platforms, a disproportionate proportion of survey responses was from New Zealand, and in the second instance Europe. Consequently, the findings may not generalise beyond those geographic cohorts. Furthermore, the range of respondents within strata might not fully represent experience, role, target group, or playing level. This should be considered when interpreting the results, making inferences, and extrapolating.

Conflict of Interest

The authors declare no conflict of interests.

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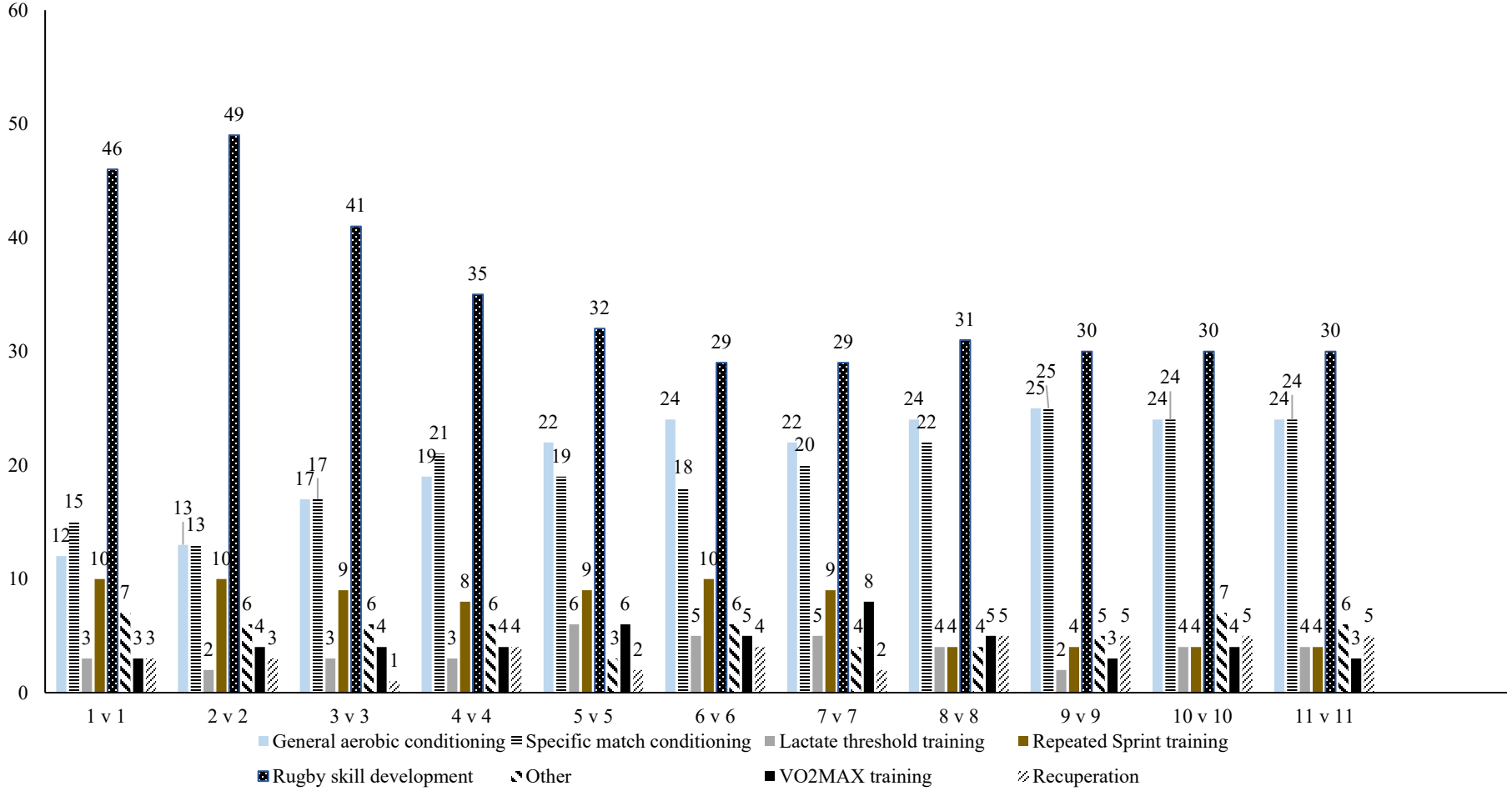
Appendix 1: Differentiated training goals for coaches' top-five SSG formats preference (% SSG-specific choice)



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Coaches' perceptions of their work in an elite youth sport setting

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ABSTRACT
This study explored coaches' experience of working in a high-performance youth sport pathway program and their beliefs about coaching. This was a qualitative study utilising semi-structured interviews with 9 members of the coaching set-up. The data was analysed through an inductive thematic approach. Although research has suggested that the coach plays a critical role in skill development at the youth high-performance level, the coaches believed that their role extends beyond this to provide a positive overall experience that supports player retention. They believed that a crucial factor in whether youth athletes continue their sport participation is the coach-athlete relationship, and these coaches saw their work 'holistically' to develop good people as well as good players. While skill development and wellbeing of players was widely recognised and acknowledged by the coaches as part of their role, it was also established that there is little attention paid to the coaches' development and wellbeing in undertaking that role.

1. Introduction

In addition to the sport specific playing ability development, coaches in high-performance youth sport development contexts play an important role in players' lives and personal development (Stratchan, Côté & Deakin, 2011). The development of players may relate to the development of physical and sport specific movement skills as well as psychosocial learning experiences (Côté & Fraser-Thomas, 2007). Coaches are also influential and instrumental in shaping the welfare and optimal functioning of sport participants (Adie, Duda, & Ntoumanis, 2012). As such, high-performance youth sport has the potential to be a context for the promotion of positive youth development, professionally and personally when an environment is intentionally created for this purpose and when competencies are promoted in a deliberate and planned manner (Camiré, Trudel, & Forneris, 2014; Fraser-Thomas, Côté & Deakin, 2005). This study investigated coaches' experience of working in a youth squad high-performance pathway sport program in South Australia. The program nurtures a pathway to professional sport proposed through enhanced coaching and training, and by offering the opportunity for participation in competitions and national championship carnivals at a high-performance youth level. The youth squad program consisted of male and female squads, from Under 15 through to Under 19 age levels.

1.1. Why we need to understand coaches' perceptions of their work

Understanding coaches' perceptions of their work provides insights into the coaching behaviours they believe are constructive. What coaches emphasise and reward influences what is learnt, the emotions players attach to what is learnt, and the satisfaction players have with the coaching (Moen, Giske, & Høigaard, 2015). Performance outcomes, conduct at practice and 'game day', motivation, and emotional states are affected by the behaviour of a coach (Strachen et al., 2011). A coach's ability to create a positive coaching environment requires domain specific content knowledge about the sport (e.g., technical, tactical, strategical, biomechanical) and pedagogical knowledge about the learning process relevant to the players abilities and potential capabilities. Effective communication skills and the ability to establish a productive coach-athlete relationship are important (Moen et al., 2015). Extending the coach-athlete relationship to their wellbeing as a player and as a person is a characteristic of athlete-centred coaching (Pill, 2018).

Horn (2008) provided a model of coach effectiveness containing coach expectancies, values, beliefs, and goals as factors influencing coaching behaviour. Coaches' beliefs

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influence pedagogical decision making with the potential for idiosyncratic behaviour arising from the intuition of the coach about their everyday reality of coaching (Jones, 2006; Pill, SueSee, Rankin & Hewitt, 2022). The concepts upon which a coach maintains their representation of valued coaching behaviour influences what the coach intends to 'do' with their players (Cotê, 1998; Cotê, Salmela, & Russel, 1995). A coach's behaviour reflects their values, which is a means to evaluate the experience (Moen et al., 2015) and explain why they do as they do (Cassidy, Jones, & Potrac, 2009).

Previous research suggests that high level coaches perceive the working competencies of practice, that is the competencies developed from the experience of coaching and related to aspects of coaching in addition to player preparation, like relational development, as more important than other coaches (Mesquita, 2011). Preston, Allan, and Fraser-Thomas (2019) used the Com-B model elements: capability, opportunity, and motivation, to explore the experiences of high-performance youth hockey coaches. However, to date, there is limited consideration of the role of the coach and of coach development in high-performance youth sport settings and positive youth development. This research aimed to understand coaches' experience of working in a high-performance pathway program of youth squads and what they believed was needed to support that role. The study was undertaken prior to a proposed introduction of an externally provided Coach Developer project, which did not occur due to Covid-19 restrictions. Studying these coaches' (those who work in a high-performance youth sport setting) perceptions of their work is worthy due to the limited research in this area. This study formed part of a wider study into coach development in South Australia (Pill, Agnew, & Abery, 2021).

2. Methods

To elicit in-depth and meaningful representations and perceptions of experiences of coaching and the needs of coaching education and development in the context of a specific environment (Meyrick, 2006), a qualitative approach was utilised. Participants took part in semi-structured interviews. This study utilised an interpretivist paradigm in order to understand the meanings the participants attributed to their experiences (Poucher, Tamminen, Caron, & Sweet, 2020). Assuming that 'reality exists in the form of multiple individual mental constructions about the world, which are shaped through lived experiences' (Poucher et al., 2020, p2. Supp file), this research adopts a relativist ontology and a subjectivist and transactional epistemology in that the knowledge is created through transactions between the participant and the researchers (Poucher et al., 2020). Institutional ethics approval for this research was granted by the research team's institutional Human Research Ethics Committee (Ethics approval number: 8375).

2.1. Participants and recruitment

In total nine participants (n = 9) volunteered to participate in interviews: the sporting body Coaching Development Specialist; the externally employed program facilitator and seven coaches. Participants were recruited via a convenience sample (Patton, 2002). Details of the sporting body Coaching Development Specialist and the externally employed program facilitator were known to the research team and with their assistance relevant coaching staff were identified. The research assistant (RA) followed up with all participants to arrange a time, location, or method of convenience to undertake face-to-face interviews. Interviews were conducted where possible at the sport's high-performance facility (n = 8) or by phone at participants' request (n = 1). The semi-structured interview guide was developed by the research team for the project, influenced by the dimensions explored in the Preston et al. (2019) study: capability, opportunity, and motivation. Interview length ranged from 45-60 minutes. Interviews were audio recorded with the permission of the participant and transcribed verbatim by a professional transcription service.

Except for the externally employed program facilitator, all participants were employed by the sporting body on a full time or part time basis. The externally employed program facilitator was a former teacher, now an education consultant. Of the seven coaches who participated; five were male and two were female. Two of the seven coaches had participated in a 'Coach Enhancement Program' during the 2018/2019 season and were continuing in coaching roles in the 2019/2020 season. Three coach participants were Head Coaches and four were Assistant Coaches. As one coach interviewed was the Head Coach for two teams, eight teams across a range of player ages of the high-performance pathway program youth squads were represented (Table 1).

Table 1: Overview of representation of coaches across age ranges and amount of time in the current role.

Coach	Team	Length of time in role
Head Coach	Under 17 Male	1 year
Head Coach	Under 15 Male	1 year
Head Coach	Under 18 Female	New to role 2019/2020
Head Coach	Under 15 Female	4 years
Assistant Coach	Under 17 Male	New to role 2019/2020
Assistant Coach	Under 15 Male	1 year
Assistant Coach	Under 18 Female	New to role 2019/2020
Assistant Coach	Under 15 Female	1 year

All participants had a background in playing the sport, coaching and/or coach education allowing for a range of perspectives to add depth and rigour to the findings (Patton, 2002). The sporting body Coaching Development Specialist was responsible for recruiting coaches for the youth pathway program, providing targeted coach education programs, accreditation, and mentoring, and to ensure consistency in coaching across the program. All participants had past or current experience in playing the sport at community, high-performance or professional level. Coach participants had a broad range of coaching experience. While some were new to the current coaching position (n = 3), the remaining coaches had been in the role for between 1-4 years prior to the 2019/2020 season (see Table 1) and continuing into 2019/2020 season when the study occurred. However, all coach participants had significant past coaching experience in the sport. Six of the seven coach participants held coaching accreditation through the National sporting body and one participant held an accreditation for the sport plus a post graduate degree in coaching undertaken internationally. Two coach participants had a teaching degree, and one was in the process of completing a teaching degree.

2.2. Data Analysis

A descriptive thematic analysis was undertaken to elicit key themes and perceptions of participants (Patton, 2002). To become immersed in the data and familiar with the content (Braun & Clark, 2006), the interview recordings were initially reviewed by the research assistant (RA) with the main points summarised. This was a process of semantic coding comprising labelling text using a concept-by-concept (as opposed to line-by-line) method to identify the explicit meanings of the data (Braun & Clark, 2006; Elliott et al., 2021). Subsequently and to provide triangulation of data (Patton, 2002), all researchers read, reviewed, and coded the interview transcriptions to develop themes and associated key points (Braun & Clark, 2006). Finally, consultation between the research team using peer debriefing to help the research team examine how their thoughts and ideas were evolving established agreement on themes (Nowell et al., 2017) through a process of optimisation through aggregation of themes and abandonment of themes where there became doubt on their analytic strength (Elliott et al., 2021). The analysis was thus inductive.

2.3. Rigour

Quality in this research project is aligned to the 8 criteria outlined by Tracy and Hinrichs (2017); worthy topic, rich rigor, sincerity, credibility, resonance, significant contribution, ethics, and meaningful coherence. Given there are no studies in South Australia that investigate the perceptions of coaches of their experiences in a high-performance sport setting, this topic is worthy through providing timely, and significant insight into coach's experiences. Data collection and analysis processes contribute to rich rigor through multiple researchers coding the data and through the use of theoretical constructs to analyse the data. The research process is transparent through the detailing of methodology and the self-reflection of the researchers to identify their values throughout the process. Credibility is established through the use of thick description which provides substantial accounts and detail so that readers can come to their own conclusions about the information. Resonance is achieved through enabling readers to make connections between the findings and their own experiences. Through the in-depth contextual analysis, the findings can be considered in relation to other coaching situations thus leading to a better understanding of the phenomenon. This research offers a significant contribution through providing insight into the South Australian coaching context which has not been explored in this manner previously.

3. Results and Discussion

Participants in this study all influence coaching practice and subsequent coach and player experience. Through exploring their perceptions of coaching and the perceived work of coaches in this high-performance youth sport setting the findings from the study offer valuable data to support decision making for future coach development programs in high-performance sport pathway programs. Findings portray experiences of coaches in a specific setting and elicit some of the intricacies encompassed by the work undertaken by these coaches and are presented in themes that reflect: the role of coaches, coaching practice, and expectations for coach development with associated key points presented as sub themes.

3.1. Role of coaches

The coach plays a major role in the effectiveness of coaching practice (Côté & Gilbert, 2009). Many characteristics and desired capabilities of the coach overlap within the role of coaching practice with a range of factors impacting the very broad scope that is the work of the coach. Some of the more specific work roles identified in this research relate to the responsibility of the coach to the player(s), relationships with parents and the perceived role in attrition and retention of players in the sport. Participants identified these roles as being associated with developing and supporting players as people as well as future professionals in the sport.

3.1.1. Responsibility of coach to the player(s)

The coach was seen to have a key responsibility in developing playing skills, building relationships with players, and fostering enjoyment of the game. If the coach can develop positive relationships with athletes, the learning experience for the athlete can be maximised (Fraser-Thomas, Côté, & Deakin, 2005; Molinero et al., 2009). For example, 'if a coach can bring the best out in the player, they will achieve more and enjoy the game' (Assistant coach U17 male). If these responsibilities are enabled, it was believed that players will potentially develop respect for the coach and a passion for the game that will progress to retention in the sport even if they do not make it to the 'adult' high-performance level of the sport. This perception supports earlier work by Molinero et al. (2009) who found that both successful athletic careers and the termination of a career can be attributed to the relationship between the coach and athlete. Many of the perceived responsibilities and required capabilities the coaches discussed as beneficial to quality athlete-centred coaching fall outside of development of sport specific skills and techniques of

the game and what is needed at training and on game day and are more about developing their players as people and preparing them for the future. For example, one participant noted that coaching is 'not based on winning; [but] did players improve, what was the experience?' (Coaching Development Specialist). The perception that coaching is not about winning is contrary to the literature (Weinberg, 2000; Elliott & Drummond, 2011; Agnew, Pill, & Drummond, 2016). The Junior Sports Framework (Australian Sports Commission, 2014) advocates for safe, inclusive, and high-quality sport experiences for participants which aligns with a shift away from a focus on winning. However, previous research (Agnew et al., 2016) indicates that one of the elements that contributes to a positive sport experience for junior sport participants is success or the pursuit of success: children enjoy sport when they are winning. In addition, winning has been identified as a key motivator for participation in sports for children (Elliott & Drummond, 2011; Weinberg, 2000). Therefore, while coach development programs may promote coaching without a focus on winning, the environment in which the coaches operate may not facilitate such a perspective. Especially in the high-performance coaching context a coaches' reputation can be measured on the success of the individual or team (Gervis & Dunn 2004; Pinheiro, Pimenta, Resenda, & Malcom, 2014; Stirling & Kerr, 2008a, 2008b, 2009, 2013; Warriner & Lavallee, 2008). This research was focussed on youth squads in a high-performance program which can be a feeder program to professional teams, thus demonstrating skills and winning are essential to proving one's worth in being part of the program. Therefore, it is unrealistic to expect that a complete shift away from a focus on winning will occur. Instead, coaches are being required to consider additional responsibilities in a more holistic style of coaching to develop good people as well as athletes. Coaches' experiences as coaches have changed due to a perceived shift in the culture of coaching which was acknowledged by several participants in the current research. Previous research (Vella, Oades, & Crowe, 2011) has confirmed the shift towards a more holistic style of coaching that includes the development of life skills and was somewhat reflected by coaches in the current research. Coaches are now expected to develop more than just athletes - they are expected to play a significant role in the development of characteristics associated with being a good person which requires coaches to have skills outside of their coaching qualifications. This type of coaching is referred to as athlete-centred coaching for positive youth development (e.g., Pill, 2018). Positive youth development can be facilitated through providing training and support to coaches (Smoll et al., 2003); the importance of this concept is supported by the following participant comment: 'doesn't matter how many resources available if the quality of coaching and understanding of the player is not there' (Assistant coach U18 female).

Observations provided by the participants in this research suggested that coaches had a responsibility to develop specific characteristics in their players to 'support the learning process for players to achieve what they want to achieve, not just in sport but as a human being…promote transferable skills' (Program facilitator). Transferable skills are life skills that are needed in everyday life and include social skills, communication, and leadership (Jones & Lavallee, 2009). Coaches need to be provided with opportunities to develop skills to incorporate more holistic practices into their coaching including how to transfer the skills from the sporting context (Vella, Oates, & Crowe, 2011). This can include understanding the intentional use of coaching styles to meet player and task learning alignment (Pill et al., 2022). The characteristics the coaches identified as their responsibility for developing in their players in addition to skills specific to playing the sport are listed in Table 2.

Table 2: Characteristics identified by coaches as targets in their coaching of the 'whole' person.

Characteristics
Resilience.
Creating players who can reflect on their skills themselves.
Empowerment.
Self-efficient and self-regulated.
Self-reflective.
Leadership.
Ability to cope with challenges.
Transferable skills and transferable knowledge.
Encourage players to question not just how but why.
Problem solving.

Coaches who had been 'in the game' for a while believed that coaching now was different to their previous experience. For example, comments included that the 'culture of coaching has changed' (Assistant coach U18 female), where coaches now seek to incorporate the development of intra and interpersonal characteristics into coaching practice and 'if players have these skills, they can take them with them' (Head coach U18 female) and 'develop and grow as a person' (Head coach U15 & U17 male) not just a player. Perceived responsibilities of coaches extended from developing a player to developing a person:

> They help players with their learning processes, to be able to then achieve what they want to achieve. And that's not just in sport, but as a general human being…transferable skills for their future… (Program facilitator).

Hassanin and Light (2014) found that prioritising the development of good people can create tension between a win at all cost approach to coaching and valuing the development of athletes' desired characteristics. As previously mentioned, an integral part of being involved in a high-performance youth squad is success, particularly if participants have goals of achieving a professional contract. Therefore, it is not possible to discount the value of winning entirely. However, the development of characteristics that support the athletes in other areas of life should they not make it to the professional level may have broader benefits to sport participation.

3.1.2. Relationship with parents

The coaches believed that they have a responsibility to parents as well as players as this was a youth program. It was recognised that parents are part of the 'reality of junior sport' (Assistant coach U15 male) and play a significant role in the player experience 'positively and negatively' (Assistant coach U15 male). Coach participants identified that parents may be a challenge or an asset, either way there is the potential to place pressure on their coaching as dealing with parents is an additional time demand. In addition, if parents criticise coach decisions the youth athlete can experience heightened pressure and anxiety (Gould et al., 2008). It was considered vital that coaches develop a strong relationship with parents. Parent trust was considered important and as with players, it was considered imperative that coaching practice is transparent, with parents aware of the coach's role and player expectations. When there is a trusting and honest relationship between coaches and parents, the athlete's trust in the coach can be increased (Jowlett & Timson-Katchis, 2005; Knight & Holt, 2014). All coach participants had experience of parents attempting to influence coach decision making or placing pressure on players. Consequently, a common thought was that the coach must have strong communication and negotiation skills and management of parent involvement. In addition, the coach must be confident in their capacity to justify their actions with players to parents when challenged. Participants also acknowledged that parental satisfaction with coaches and in coach practice had the potential to influence retention in the high-performance program and the sport generally.

3.1.3. Attrition and retention

The coach-athlete relationship is a critical factor in whether young athletes continue their sport participation (Agnew et al., 2016; Wekesser, Harris, Langdon, & Wilson, 2021). The role of the coach in attrition and retention rates was raised by coaches during the interviews. However, the role of the coach in attrition rates in a high-performance pathway program, was not considered by participants to be of significant concern as player entry to the high-performance program was competitive and believed to be highly sought after. The coaches believed that players come to the high-performance program with a passion for the sport and desire to play at a high level. Retention in the high-performance program was therefore mostly seen to be based on talent. Given the athlete is rewarded for their talent (Claringbould, Knoppers, & Jacobs, 2015) by being selected into a specialised training squad, attrition may be lower than in other sport settings. However, as summarised by one participant, 'the reality of high-performance is not all will make it' (Assistant coach U17 male) and the pressures associated with performance expectations at the high-performance level can have a detrimental effect on athletes (Preston & Fraser-Thomas, 2014). As noted in participants' responses, the coaches had a strong belief that their role included developing good people as well as good athletes. This belief fosters a holistic style of coaching that can have a positive influence on the development of athletes. Therefore, along with their being selected based on talent, the holistic style of coaching which is athlete-centred may facilitate continued involvement by athletes.

The experiences of coaches in this high-performance program may differ from other youth sport settings as motivation may be higher amongst the high-performance athletes making attrition less of an issue. Retention is a key component of a coaches' role at the junior level; however, this does not appear to be the case at the high-performance junior level. While it was acknowledged by participants that enjoyment of the game, and 'wanting to play the game for the game's sake will lead to retention' (Coaching Development Specialist), and that the coach was pivotal to this, some coaches perceived 'retention not part of the role at elite level' (Assistant coach U17 male). If not selected to the high-performance pathway program, players are able to return to community level competition and this was noted as to where retention was impacted through the quality of the coach and coaching practice. There was not recognition that negative or unenjoyable experiences in the high-performance pathway program may turn players away from the sport. It was considered however, that retention may be impacted by the fact that once players return to community level involvement in the sport there is potentially not the same level of coaching quality and support, and also the standard of competition is lower which influence the players interest or passion to continue. The coaches felt that retention was more likely impacted by youth club players aged between 16 to 20 not making the high-performance program as the goal of being involved in the pathway program was to progress to the high-performance state level:

> it's sort of a bit of a perception that if you don't make state squads, and that's sort of seen as the purpose of playing [sport] is to play state [sport] play for Australia…if they don't make a state squad, their sort of passion for the game filters off (Head coach U15 female).

If players at club level who believed they should be in the high-performance pathway program do not make it to the program it was felt that passion for the game has the potential to diminish due to the: 'limited quality opportunities at local level and lack of quality coaching…so lose interest' (Assistant coach U18 female). It was also noted by this participant that this was an age where other factors impact desire to play sport: 'we lose a lot of players between the age of 16 and 20, they get their license, there's other things to do, it's not so much fun…'

3.2. Coaching practice

A clear focus of coaching practice presented by the participants was the opportunity to practice athlete-centred coaching highlighting that players' personal as well as professional needs, goals, and health and wellbeing were considered. This was seen as a positive shift in coaching focus away from 'player skill development and championship results' (Head coach U15 female). As proposed by one participant but alluded to by others, it is 'important to develop people as a whole not just [sport] players… a lot more to coaching than knowing the game… it's about knowing your people' (Coaching Development Specialist), and when coaches reflected from the player perspective, it was that 'players want a coach that knows what they are talking about but also want a coach who knows them as a person' (Coaching Development Specialist).

Continuing professional development is a key component of being an effective coach and keeping skills and knowledge relevant (Nash, Sproule, & Horton, 2017) but also being prepared to be 'open to new methods' (Assistant coach U17 male). The participants in this research considered that coaching practice is influenced by the extent of opportunities for experience and education which has an important place in 'broadening skill sets' (Head coach U15 female). Participants actively sought opportunities formally and informally. All participants who were coaches had a minimum Level 2 national accreditation in the sport with all also having undertaken other forms of coach development including online courses and workshops run through the state sporting body, the national sporting body, and external agencies. Formal continuing professional development programs have been shown to improve coach retention, raise coaching standards and enhance coach learning (Nolan, 2004; Whitmore, 2002). However, they may not improve competence or change behaviours if they are compulsory (French & Dowds, 2008). For coaches in this research, additional training and education opportunities were mostly self-initiated in order to improve their skills and knowledge, and to keep up with the evolving changes in coaching practice. It was identified by participants that mentoring from other coaches was valued for professional as well as personal development and played 'a key part of coach development' (Head coach U15 & U17 male), valuing 'seeking feedback from other coaches trying to learn off them…get other coaches to watch me and then get some feedback' (Assistant coach U15 male). The coach participants all appeared self-directed and motivated to undertake additional personal development and although encouraged this was not a requirement of the state sporting body to maintain their coaching positions. One participant admitted, 'I would say the bulk of my learning has come from my own research I would think…I'm just a nerd who goes online and reads and watches stuff' (Head coach U18 female).

In this way, coaches are self-regulating their professional development and taking responsibility for their learning (Nash, Sproule, & Horton, 2017). Additionally, all coaches interviewed had previously coached or were still coaching community level in the sport or supporting other areas of the sport in addition to their roles in the high-performance pathway program youth squads. All were also currently playing or had played the sport at either community, state, or international levels. This combination of developed practical and theoretical skills was acknowledged by coaches as a key factor in how they approached their coaching practice.

Participants were asked to identify the key characteristics for quality coaching practice and responses were consistent across all participants. These characteristics ranged from technical knowledge, pedagogical knowledge and skills often referred to as the 'soft' skills, such as empathy and trust. These characteristics add to the those compiled by Tušak and Tušak (2001) who described the successful coach as being a good educator, highly motivated, flexible, having sound reasoning and self-confidence. Quality sport coaches also need to have transparent leadership skills and care about the safety of their athletes (Perez Ramirez, 2002). Becker (2013) determined that the seven qualities in a coach that positively impact athlete development and performance were coaches who were positive, supportive, individualised, fair, appropriate, clear, and consistent. The conception of quality coaching practice can be summed up by the following quote that reflects the perceptions of many participants; 'coaching traditionally skills focussed, it is important to focus on player needs; there are plenty of coaches with the technical skills but not all have the holistic skills…quality coaches can see beyond themselves' (Coaching Development Specialist).

3.3. Expectations for coach development

Participant experiences in this research indicate that coach development programs are valuable as coaches' desire to learn and improve their coaching skills and scope of practice. While there has been a lack of formalised, effective models for coach development, continued professional development that can be conducted in situ through mentoring or collaborative approaches is supported by coaches (Nelson, Cushion, & Potrac, 2013) as the active learning processes are easily translatable to practice (Coffield, 2000). Therefore, working with a coach development specialist facilitates a way to improve in situ rather than offsite external courses undertaken outside of the coach's work role and paid time. All participants saw the value in participating in coach development programs. Those about to embark on season 2019/2020 were 'excited' and 'motivated' about the prospect of having an external coach development facilitator to support them in gaining new knowledge, enhancing existing skills, and looking at coaching practice from new perspectives. For example, '[the sport] is a unique space, and it's got a lot of history that goes with it…it would be really cool for it to go a bit more contemporary' (Assistant coach U15 male). Participants were receptive to exploring new ideas and methods, as 'the game is constantly evolving therefore coaching methodology needs to also be open to different points of view' (Assistant coach U17 male). A key point made in support of coach development was that there is 'a lot of emphasis on improving players, less focus on reviewing coaching performance' (Head coach U18 female) so support from the sporting body management in providing additional opportunities in coach development was embraced. Typical of the sentiment was that, although these coaches were self-motivated to seek coach extensive education it was acknowledged that 'can't rely solely on self-initiation of coach development' (Assistant coach U15 male). Self-motivation has previously been found to be one of the key factors in continuing professional development, along with certification, needing to remain competitive in the industry and employer requirements (Jakovļeva & Žīdens, 2011). A key point for consideration in this study is that these coaches were experienced in the sport and coaching, and their roles were paid positions in contrast to many community sporting coaching roles. There was the suggestion in this research that 'coaches often work in isolation' (Head coach U18 female), with the expectation from many participants that the inclusion of a formal coach development program would encourage more collaboration, peer support and mentoring, and sharing of ideas, resulting in the capacity to 'enhance strengths and address fallbacks' (Assistant coach U15 male).

A pilot Coach Enhancement Program had been conducted in the previous season. Those who had completed the pilot Coach Enhancement Program (n=2), found the focus on change in 'coaching to player development rather than championships' (Head coach U15 female) beneficial, and their improved confidence and clarity of messages and purpose was validated in

feedback from players. It was commonly noted that there was a 'growth area in coach development in looking after the whole person' (Assistant coach U15 male) and this is not necessarily formally taught to coaches, and so perceived as an area lacking in more generic coach development courses. The shift away from a focus on championships is an interesting conundrum given young athletes know who has won despite the move to remove scoring from some junior sports (Agnew et al., 2016) and is unlikely to be the case in the context of high-performance youth development squads. Therefore, winning is still perceived as important to the junior athletes despite the shift away from such a focus. The need to develop players supports the need for coach development programs that go beyond skills and have more of a focus on the whole person and well-being. Some concerns were raised by participants mainly around processes of the proposed Coach Development Program that were new to them, such as observation and reflection on their coaching behaviour. Participants of the pilot program would have liked more time with the coach developer and felt that the information and the pedagogical knowledge was at times 'overwhelming' (Assistant coach U15 female) as there was much to share and discuss, but time with the coach developer was limited. These factors were addressed and considered in the 2019/2020 season format of the proposed Coach Development Program in an attempt to enhance the benefits of the program and encourage participants to be engaged in the process and to motivate behaviour change. Kokko, Kannas, and Villberg (2006) and Skille (2010) have found that sport settings can be a key environment for promoting health as well as social good. Continued investment and resources in health and sport promotion programs is needed in sports clubs to facilitate sustainable change in behaviour (Donaldson & Finch, 2011).

Through consideration of themes developed from the data and discussed above it can be concluded that the coaches believed that they were creating environments that were about more than the sport, although the reason they were in the position to create such environments was their role in developing the players sport performance potential. In desiring to create an environment for the development of the 'whole' player, ability to develop honest relationships with players as well as their parents was necessary because of the age of the players. This ability to develop honest relationships extended to enabling players and parents to realise that 'not everyone will make it' through the program. While the coaches were pointed to creating an environment for player development, the coaches believed more could be done by the sport to create an environment for coach development. This is summarised as Figure 1.

3.4. Study strengths and limitations

A strength of this study is the qualitative methodology selected to promote insight, affinity and appreciation into the perception of coaches and their work in an elite youth sport coaching setting. A limitation is the sample size and single point in time data collection. Future research on coaching in youth sport high-performance settings is required in other sports and using a variety of research perspectives.

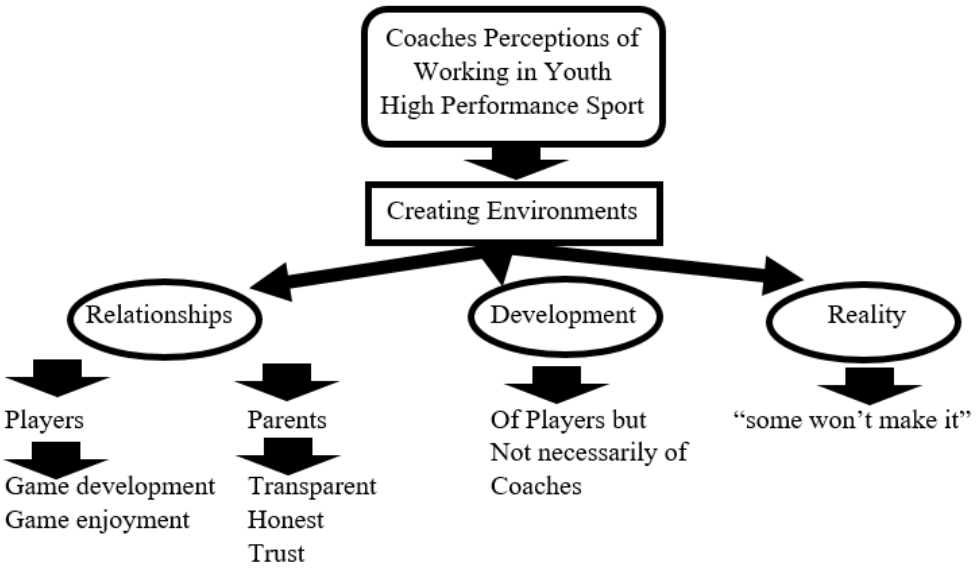

Figure 1: Coaches perceived their work to be creating environments where relationships with player and parent, athlete-centred coaching for player development, and being realistic about the outcome of program for some players, are present.

4. Conclusion

The findings of this study provided insight into perceptions of Australian coaches and coaching, and the role of the coach in the player experience and developing the sport and the players involved in high-performance pathway program youth squads. It is evident that coaches want more support and opportunities in coach development and acknowledge the potential benefits: to themselves in increasing their knowledge, skills, confidence, and quality of coaching provided; to the players' enjoyment of playing the game at a high-performance level and retention in the sport overall, and to other contributing stakeholders.

While skill development and wellbeing of players was widely recognised and acknowledged by the coaches in this study as part of their work role it is also recognised that there is little attention paid to the coaches' development and wellbeing. This stresses the need for more formal Coach Development Programs to be initiated and supported by sporting bodies and for the experiences of coaches to be recognised and used in the development of such programs. This is more likely to occur at the high-performance level of sport where coaching roles are paid and considered work, however, further research in this area would also benefit coaches and coach development at the community level in unpaid roles where the need exists but is often not implemented due to lack of resources and funds. Further research is warranted into how coaches can best develop their own coaching practice in a way that is acceptable to their needs and capacity, and to the benefit of the players who they are ultimately responsible for.

Conflict of Interest

The authors declare no conflict of interests.

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Run faster, bowl faster: In-match analysis of elite female cricket pace bowlers

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ABSTRACT

Pace bowlers who release the ball at a higher velocity have been shown to both reduce the scoring ability of batters and dismiss batters more often. Run-up velocity is a key parameter consistently shown to influence ball velocity in male pace bowlers, however this has yet to be evaluated in female pace bowlers who have different anthropometric characteristics, strength, and bowling biomechanics. The aim of this study was to analyse in-match global positioning system (GPS) unit data and ball velocity data to determine whether characteristics of the run-up and delivery stride were associated with ball velocity in elite female pace bowlers. Wearable device (gyroscope, accelerometer, and GPS) data and ball velocity data were collated from 28 elite female pace bowlers participating in a T20 competition. Linear regressions were conducted on 1050 bowling deliveries for both absolute ball velocity (raw data) and relative ball velocity (percent of individual's maximum). Univariate analyses found absolute ball velocity was strongly associated with run-up distance ($p = 0.002$), average run-up velocity ($p = 0.010$), maximum run-up velocity ($p < 0.001$), maximum velocity during delivery stride ($p < 0.001$), peak resultant acceleration ($p = 0.013$), and peak roll ($p = 0.031$). Relative ball velocity was most strongly associated with maximum run-up velocity ($p = 0.004$) and maximum velocity during delivery stride ($p < 0.001$). Multivariate analysis found absolute ball velocity was strongly predicted by maximum velocity during delivery stride ($p < 0.001$), peak resultant acceleration ($p = 0.003$), run-up distance ($p = 0.008$), and peak roll ($p = 0.043$). Bowlers should aim to increase their run-up velocity, particularly during the delivery stride, to increase ball velocity. However, this should be in the context of individual factors such as biomechanics and strength.

1. Introduction

Pace bowlers are integral to a cricket team's performance (Johnstone et al., 2014). Pace bowlers who release the ball at a higher velocity have been shown to both reduce the scoring ability of batters and dismiss batters more often (Malhotra & Krishna, 2017). This is attributed to batters having less time to position their body effectively to play a shot (Müller et al., 2009). As such, much attention for pace bowling performance has been directed at increasing ball velocity. To date, research in this area has focused on anthropometric characteristics, strength, and biomechanics in male pace bowlers.

Anthropometric characteristics may influence ball velocity. Taller bowlers have the advantage of a higher ball release which helps optimise the delivery angle, bounce off the pitch, and force production assisting greater ball velocity (Johnstone et al., 2014). Elite male bowlers are heavier and carry more lean mass than junior representatives (Pyne et al., 2006). Larger chest girth and lower skinfold measures have been associated with increased ball velocity in male amateur level cricketers (Portus et al., 2000).

Strength and power are likely to influence ball velocity, although research in this area is limited and findings have not been consistent across studies (Feros et al., 2019; Kiely et al., 2021; Pyne et al., 2006; Ramachandran et al., 2021). Force production from the upper body may positively influence technique and has

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been reported to account for 36-45% of variance in ball velocity (Ramachandran et al., 2021). Elite male bowlers were shown to be more powerful in bench press throw and deltoid throw performance than junior bowlers (Pyne et al., 2006). In sub-elite (local club level) male cricketers, 1-repetition maximum pull-up strength, a measure of upper body pulling strength, correlated with both mean and peak ball release velocities (Feros et al., 2019).

Several biomechanical factors have also been identified which are associated with faster bowling velocities. A more extended front knee during the front foot contact phase of the delivery (Portus et al., 2004; Portus et al., 2000) and a maximum hip shoulder separation angle which occurs later in the delivery stride (Portus et al., 2004) are associated with faster ball velocities. The larger hip shoulder separation angle creates a slingshot like effect during the bowling action. Faster bowlers also display higher braking and vertical impact forces (Portus et al., 2004).

Anthropometric, strength, and biomechanical factors may influence ball velocity, however a recent meta-analysis by Ramachandran et al. (2021) found run-up velocity to be the parameter most strongly correlated with ball velocity. The eight studies which contributed to this finding included six sub-elite-to-elite male cohorts, with correlation coefficients between 0.499-0.737 (strong) (Ferdinands et al., 2010; Glazier et al., 2000; Glazier & Wheat, 2014; King et al., 2016; Middleton et al., 2016; Salter et al., 2007). Interestingly, one study that included an amateur cohort (Middleton et al., 2016) and another study on competitive club-level bowlers (Feros et al., 2019) did not find similar correlations. Three additional studies not included in the meta-analysis also studied high-level bowlers and found strong correlations between run-up velocity and ball velocity (Duffield et al., 2009; Kiely et al., 2021; Worthington et al., 2013). These findings highlight the importance of run-up velocity in high-level male pace bowlers. To date, no studies have analysed whether similar correlations exist with female pace bowlers. Limited research on elite female pace bowlers has shown that their run-up speed is similar to (Savage & Portus, 2002) or slower than (Felton et al., 2019) elite male pace bowlers, with slower ball velocity.

Considering that female pace bowlers have different anthropometric characteristics (Stuelcken et al., 2007), bowling biomechanics (Felton et al., 2019), and likely strength and power (Bartolomei et al., 2021) compared to male pace bowlers, it follows that factors contributing to ball velocity may be different in female bowlers and needs to be researched. A limitation of previous studies in male pace bowlers is that all but one of the previous studies (Salter et al., 2007) used a cross-sectional between-bowler study design, therefore omitting numerous individual factors which may also contribute to ball velocity. A further limitation of these studies is that they were all conducted indoors, with artificial surfaces, indoor shoes, and dimension constraints potentially affecting run-up. All of these factors are likely to produce kinematic results that are different to that of a real world (outdoor in-match) scenario. Therefore, the aim of this study was to analyse in-match data from wearable devices (gyroscope, accelerometer, and global positioning system (GPS)) and ball velocity data over a season to determine whether characteristics of the run-up and delivery stride were associated with ball velocity in elite female pace bowlers.

2. Methods

2.1. Study design

Retrospective cohort study. Ethical approval was obtained from La Trobe University Human Research Ethics Committee (HEC 20058). Individual consent specific to this study was waived given the data was part of routine monitoring.

2.2. Participants

Twenty-eight female pace bowlers competing in the Australian Women's Big Bash League (Twenty-20 (T20) competition) 2019-20 season participated (24.9 ± 5.1 years at the start of the season). Bowlers did not have any injuries which affected their ability to perform as a bowler.

2.3. Run-up and delivery stride characteristics

Bowlers wore a Catapult Optimeye S5 GPS unit (Catapult Innovations, Melbourne, Australia) that was held within a GPS vest worn across the bowlers' upper back. Each unit collected data at 100 Hz. To be included in the study, the bowler's deliveries needed to be auto detected by a bowling algorithm within the Catapult software (Openfield, Catapult Innovations, Melbourne, Australia). For a delivery to be detected, predetermined criteria need to be met across gyroscope, accelerometer and GPS data (McNamara et al., 2015). The algorithm has been shown to be sensitive in training (99%) and competition (99.5%) (McNamara et al., 2015).

Run-up data extracted from the GPS unit included distance, average velocity, maximum velocity, and velocity at the point of delivery. Delivery stride characteristics obtained from the inertial sensors were peak resultant accelerations (obtained from resultant of the peak x,y,z accelerometer outputs), peak roll angular velocity (equivalent to trunk lateral flexion velocity during bowling), and peak yaw angular velocity (equivalent to rotation velocity at the thoracic spine during bowling) (McNamara et al., 2018).

2.4. Ball velocity

Ball velocity was captured during televised matches via a mounted radar gun (Stalker Pro II, Stalker Sports Radar, Piano, Texas) positioned on a tripod outside of the boundary and behind the bowler's arm. This data was coded by the analyst from each of the teams using specialist software (Fair Play Sports Analysis Systems, Fair Play Pty Ltd, Jindalee, QLD) and subsequently uploaded to a central Athlete Management System (Fair Play AMS Pty Ltd, Jindalee, QLD).

2.5. Strength and power

Measures of bench pull (upper body pulling strength) (Bilsborough et al., 2015), counter-movement jump test (lower body power) (Yingling et al., 2018) and isometric mid-thigh pull (lower body pulling strength) (McGuigan & Winchester, 2008)

were included as covariates in analyses to control for the potential confounding factors of strength and power. These measures are routinely completed in a standardised manner throughout the season and recorded in the Athlete Management System. The best performance during the season was included in analyses.

2.6. Statistical approach

Absolute ball velocity (raw data) was converted to a percent of the individual's maximum ball velocity recorded in the data set (relative ball velocity). Relative ball velocities ranged from 66-100%, median 93% and interquartile range 90–96%. Lower velocity deliveries were likely the result of the bowler deliberately varying their run-up and delivery to tactically deliver a slower ball. To avoid potential bias of slower deliveries, the lower quartile of deliveries was excluded (i.e., cut off 90%).

Descriptive statistics (mean and standard deviation) were calculated for ball velocity and run-up metrics. Linear regression was used to evaluate the relationship between ball velocity (dependent variable) and delivery characteristics (independent variables): delivery run-up distance, average run-up velocity, maximum run-up velocity, maximum velocity during delivery stride, peak resultant, peak roll, and peak yaw. Data did not satisfy the Shapiro-Wilk assessment of normality (all $p < 0.001$), however from visual inspection of frequency histograms and inability to improve normality of the data with transformation, it was deemed satisfactory to assume normality for analyses. Generalised estimating equations (GEE) with a linear model and exchangeable correlation structure were used to account for repeated measures within individuals. Univariate analyses for each run-up and delivery stride variable were conducted for both absolute ball velocity (raw data) and relative ball velocity (percent of individual's maximum). Absolute ball velocity was modelled with the covariates of age and strength and power characteristics (bench pull, vertical jump, mid-thigh pull) controlled for. Variables with a p-value <0.05 from univariate analyses were included in multivariate analyses, excluding collinear variables determined by collinearity diagnostics. Analyses were performed using SPSS (Version 25.0. Armonk, NY: IBM Corp.).

3. Results

A total 1050 bowling deliveries for the 28 bowlers were included in analysis. The mean number of included deliveries per bowler was 47 ± 24. Mean maximum absolute ball velocity recorded for the season was 113 ± 6 km/h. Mean average run-up distance, average run-up velocity, maximum run-up velocity, and maximum velocity during delivery stride recorded for each bowler across the season were 14.2 ± 3.0 m, 4.5 ± 0.3 m/s, 6.0 ± 0.5 m/s, and 5.4 ± 0.4 m/s respectively. Mean best performances for bench pull and mid-thigh pull (both normalised for body weight), and vertical jump were 3.94 ± 0.43, 0.86 ± 0.12, and 49 ± 6 cm respectively.

Univariate analyses found that run-up velocity metrics (all $p \leq 0.010$), run-up distance ($p = 0.002$), and peak resultant acceleration ($p = 0.013$) strongly predicted absolute ball velocity (Table 1). Age (B = 0.037, 95% CI -0.392–0.465, $p = 0.867$), and bench pull ($R^2 = 0.054$), vertical jump ($R^2 = 0.107$), and mid-thigh pull ($R^2 = 0.002$) for the season did not independently explain the variance in absolute ball velocity. Bench pull, vertical jump, and mid-thigh pull did not predict run-up velocity metrics (all $p > 0.05$), with the exception of bench pull and maximum run-up velocity ($p = 0.039$).

Multivariate analysis for absolute ball velocity included run-up distance, maximum velocity during delivery stride, peak resultant acceleration, and peak roll (average run-up velocity and maximum run-up velocity were collinear with maximum velocity during delivery stride). Absolute ball velocity was strongly predicted by maximum velocity during delivery stride (B = 1.7358, 95% CI 1.019–2.457, $p < 0.001$), peak resultant acceleration (B = 0.387, 0.128–0.647, $p = 0.003$), run-up distance (B = 0.441, 0.116–0.766, $p = 0.008$), and peak roll (B = 0.002, 0.000–0.003, $p = 0.043$).

Average run-up velocity ($p = 0.027$), maximum run-up velocity ($p = 0.004$), and maximum velocity during delivery stride ($p < 0.001$) strongly predicted relative ball velocity (Table 1). Due to collinearity of average run-up velocity and maximum run-up velocity with maximum velocity during delivery stride for relative ball velocity, only maximum velocity during delivery stride met the inclusion criteria for multivariate analysis and hence multivariate analysis for relative ball velocity was not conducted.

4. Discussion

Run-up velocity is an important and modifiable factor contributing to ball velocity in pace bowlers (Ramachandran et al., 2021), however prior to this study the relationship between the two had not been investigated in female pace bowlers in the literature. This study analysed in-match data across a cricket season and found a positive association between ball velocity and: average run-up velocity, maximum run-up velocity, and maximum velocity during delivery stride. Furthermore, analyses controlled for individual factors of age and strength/power, supporting the idea that the faster a bowler runs up, the faster they are able to bowl relative to their own capacity.

The findings from this study suggest that an individual increasing their maximum run-up velocity and maximum velocity during delivery stride by 1m/s will result in the ball being delivered approximately 1km/h faster. However, it is misleading to conclude that bowlers should solely train to improve their sprint velocity to bowl faster. Faster sprint velocity does not necessarily translate to faster run-up and in turn faster ball velocity (Kiely et al., 2021). Each individual bowler is likely to have an optimum run-up speed, beyond which ball velocity and accuracy are compromised (Bartlett et al., 1996; Worthington et al., 2013). Elite male T20 pace bowlers have been shown to have a run-up velocity which is close to their maximal sprint velocity (Sholto-Douglas et al., 2020). Further research is needed to understand what percentage of maximum velocity female pace bowlers typically operate at, and whether this can be manipulated to optimise ball velocity.

Table 1: Relationship between run-up and delivery stride characteristics and absolute (raw data) and relative (percent of individual's maximum) ball velocity. Data presented with 95% confidence interval. N=1050 deliveries included for 28 bowlers.

Run-up and delivery stride characteristics	**Absolute ball velocity (km/h)**		**Relative ball velocity (%)**	
	Slope (B)	*p*-value	Slope (B)	*p*-value
Run-up distance (m)	0.523 (0.193–0.852)	0.002	0.022 (-0.085–0.129)	0.690
Average run-up velocity (m/s)	1.815 (0.425–3.205)	0.010	0.886 (0.101–1.671)	0.027
Maximum run-up velocity (m/s)	2.497 (1.217–3.776)	<0.001	1.109 (0.360–1.859)	0.004
Maximum velocity during delivery stride (m/s)	1.916 (1.025–2.807)	<0.001	1.013 (0.480–1.547)	<0.001
Peak resultant acceleration (m/s^2)	0.448 (0.095–0.800)	0.013	0.194 (-0.012–0.401)	0.065
Peak roll (deg/s)	0.002 (0.000–0.004)	0.031	0.001 (0.000–0.002)	0.052
Peak yaw (deg/s)	0.001 (-0.001–0.002)	0.339	0.001 (0.000–0.002)	0.132

For sprint velocity to translate to bowling run-up velocity, the bowler must firstly be able to maintain run-up velocity into the delivery stride. Secondly, the bowler must then transfer linear momentum from the run-up to angular momentum of the delivery which requires a high braking ground reaction force and coordinated strength to effectively decelerate the body (Callaghan et al., 2021; Ferdinands et al., 2010). It has been postulated that elite female pace bowlers may adopt a slower run-up velocity to allow for controlled execution of the bowling action to account for the likely lower relative strength compared to their male counterparts (Felton et al., 2019), however this has not been researched. Whilst strength may be a factor between sexes, the variable strength between the female pace bowlers in this study did not clearly explain run-up velocity.

Elite female pace bowlers may compensate for a slower run-up velocity with increased pelvis and shoulder rotation compared to male counterparts (Felton et al., 2019). Trunk lateral flexion, measured as peak roll (McNamara et al., 2016), may contribute up to 13% of final ball release velocity (Bartlett et al., 1996). Trunk lateral flexion may be higher in bowlers with a side-on action where the non-bowling arm has a faster path (extension and adduction) compared to bowlers with a more front on action. As such, front-on bowlers may rely more on run-up velocity to generate pace on the delivery (Kiely et al., 2021; Ramachandran et al., 2021). Therefore, individual bowling actions may dictate the relative importance of run-up velocity and delivery stride characteristics. Bowling biomechanics were not included in this study, hence future research and individual assessments should include both run-up velocity and bowling biomechanics to assess their relative importance. Future research should also control for bowler height and lean mass which is a limitation of this study.

The strength of this research being in-match data for ecological validity is at the expense of a lack of control over extraneous variables such as match situation and fatigue. Due to the nature of T20 cricket, players vary their pace, line and length more often than in other formats of the game. Whilst absolute slower balls were excluded from the data analysis, small deliberate changes in pace will still have been captured and analysed against run-up velocity. The intra-individual analyses may have captured how individuals use run-up velocity and delivery characteristics to vary the ball velocity, whether consciously or not.

Equipment is another likely source of variability in the measure. The fixed radar gun used to measure ball velocity was set up by the broadcast companies, therefore the positioning was unable to be directly controlled for the purpose of this study. The inherent margin of error between GPS units was addressed by ensuring players wore the same unit so that any error was consistent for within-player analysis. The algorithm used to detect bowling deliveries was developed using male pace bowlers and therefore the thresholds may be less sensitive for female bowlers. From cross-checking with match scorecards, it is estimated that 40 (3.7%) deliveries did not trigger the automatic detection. These missed deliveries were bowled at a lower velocity and/or produced less roll (trunk lateral flexion as determined by the Openfield software) during the bowler's action, which were likely deliberate attempts to bowl a slower ball. Such balls may have introduced bias to the study and would likely have been excluded by the lower quartile cut-off.

4.1. Conclusion and future directions

Ball velocity is an important performance metric for pace bowlers. Run-up velocity, particularly maximum velocity during delivery stride, is a key factor associated with ball velocity in elite female pace bowlers. Bowlers should aim to increase their run-up velocity to increase ball velocity, however this should be in the context of individual factors such as biomechanics and strength. To further understand the relationship between run-up and delivery stride characteristics and ball velocity, future research may investigate the contribution of a bowler's anthropometric characteristics, bowling technique, and maximal sprint velocity. Future research should also seek to elucidate the relationship between the aforementioned factors and bowling accuracy, another key component of pace bowling performance. Subjective ratings of effort and qualitative information from bowlers regarding how they try to increase or vary ball velocity may lend to coaching cues to more effectively translate the findings of this research to practice.

Conflict of Interest

The authors declare no conflict of interests.

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Associations between physical activity and stress levels in medical doctors working in New Zealand and Australia during initial COVID-19 restrictions

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Workplace stress

ABSTRACT

In 2020, the world was gripped by the COVID-19 pandemic which put an unprecedented strain on health care workers. The aim of this study was to assess the effects of the Australian and New Zealand lockdowns on physical activity, depression, and anxiety in medical doctors. We hypothesized that during stressful times such as the COVID-19 pandemic lockdown, physical activity would have a positive effect on the mental health of medical doctors. Convenience sampling (using mass emailing via professional networks including medical associations) and snowball sampling were used during the early period of COVID-19 government mandated restrictions (25 March to 27 April 2020) in New Zealand and Australia. All registered medical doctors working in New Zealand and Australia were eligible to participate in the survey. The short survey collected information demographics, levels of physical activity and mental health using the International Physical Activity Questionnaire: Short Form and the Depression, Anxiety and Stress Scale-42. Of 469 participants who completed the survey, over 81% met the recommended physical activity levels (150 minutes of at least moderate-intensity physical activity/week). Physically inactive New Zealand and Australian medical doctors reported significantly higher depression ($p = 0.006$), anxiety ($p = 0.008$) and stress ($p = 0.002$) scores compared to their active counterparts. This study demonstrated that less physical activity was associated with higher anxiety and depression in medical doctors. A key recommendation from this study is to incorporate greater access to physical activity in healthcare settings for medical doctors.

1. Introduction

Since late 2019, the world has been gripped by a pandemic caused by a novel Coronavirus- COVID-19 (Pappa et al., 2020). The virus was first identified in Wuhan, China (Huang et al., 2020) and spread to every continent. (Pappa et al., 2020). Following the confirmation of this pandemic by World Health Organization (WHO) on March 11th 2020 (Pappa et al., 2020), the respective governments in New Zealand (Keogh, 2020) and Australia (Burke, 2020) acted swiftly to institute state and nationwide lockdowns. Medical doctors, like the rest of the populace, were impacted by the severe lockdown restrictions which had potentially significant impacts on access to physical activity.

Physically active individuals have a reduced risk of developing mental illness compared to those who are inactive (Taylor, Sallis, & Needle, 1985). Additionally, physical exercise has been associated with the successful treatment of depression, anxiety and psychological stress (Callaghan, 2004; Guszkowska, 2004; Taylor et al., 1985). Hypothetically, during the lockdown when physical activity was restricted, an individual's ability to take part in exercise as a stress buffer was likely to be substantially reduced as many recreational opportunities were prohibited (e.g.,

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no sporting competitions, gyms closed, activities with others individuals outside one's household limited) (Australian Government, 2020; New Zealand Government, 2020). This reduced access to activity may have compounded the stress of medical doctors, potentially impacting their wellbeing.

Data from previous epidemics/pandemics (i.e., Ebola and SARS) have shown that health care workers (HCWs) are particularly vulnerable to psychological and mental health issues. Factors thought to be related to increased stress include increased workload, lack of personal protective equipment, sleep deprivation, fear of becoming infected, anxiety about making ethical decisions while providing medical care, isolation and stress, working long shifts and having little information about COVID-19-related patient prognosis (Wu et al., 2009). Working in such an unpredictable environment could further aggravate the already existing "compassion-depleted state", leading to burnout (Kumar, 2016).

Prior to the COVID-19 pandemic, mental health specialists had reported a higher incidence of psychological distress amongst doctors as compared to the general population (Feeney et al., 2016). These mental ill-health effects in combination with doctor burnout is not unique to Australia and New Zealand, having been reported globally in the medical profession (Shanafelt et al., 2015; Sharma, Sharp, Walker, & Monson, 2008; Thommasen, Lavanchy, Connelly, Berkowitz, & Grzybowski, 2001). Work-related mental ill-health which is not diagnosed or is not well-treated may not only affect a HCW's capacity to care for their patients but may also illicit negative consequences on the HCW's health (Wallace, Lemaire, & Ghali, 2009).

The COVID-19 pandemic has challenged the health care sector globally. A theoretical model proposed by the Australian Government in the early phase of the COVID-19 pandemic showed that an unchecked outbreak of COVID-19 would exceed the intensive care unit (ICU) bed capacity in Australian hospitals by 5 times (35000 ICU bed occupancy as compared to 7000 in routine expanded capacity) (Australian Government, 2020). Increased demand on resources in hospitals and primary care has been predicted and witnessed in other parts of the world (Christen et al., 2020). HCWs, as a consequence, worked more than their normal hours, were required to execute new policies, had to ration life-saving equipment and health-protecting resources, had restricted autonomy with extreme physical tiredness, mental fatigue and insomnia; with negative impacts on physical and mental health (Kang et al., 2020; Rossi et al., 2020; Shaukat, Ali, & Razzak, 2020).

The primary aim of this study was to assess the effect of the COVID-19 pandemic restrictions on the physical activity and mental health of doctors in Australia and New Zealand. It was hypothesized that the mental health of doctors in this stressful work environment may be negatively impacted by a reduction in physical exercise levels secondary to the imposed restrictions. The study aimed to inform the medical sector about the physical and mental health impact on the doctors who offer services when under extreme duress in a pandemic.

2. Methods

We used Qualtrics survey software (Qualtrics, Provo, Utah) to collect cross-sectional data during the lockdown stages (April-June 2020) of government-led containment measures in New Zealand and Australia (see Table 1 for restrictions) (Wikipedia, 2020a) (Wikipedia, 2020b). The containment measures were aligned with WHO guidelines (World Health Organisation, 2020). The research was approved by the local Institutional Human Ethics Committee in New Zealand and Australia (New Zealand reference # 2020-18, Australia reference # 2057014.1). The study adhered to current epidemiological guidelines (Strengthening the Reporting of Observational Studies in Epidemiology- STROBE) (Von Elm et al., 2007). All participants provided informed consent at the start of the survey.

Convenience sampling (using mass emailing via professional networks including medical associations) and snowball sampling were used during the early period of COVID-19 government-mandated restrictions (25 March to 27 April 2020) in New Zealand. All medically trained health professionals working in New Zealand and Australia were eligible to participate in the survey.

Table 1: Covid-19 restrictions to human movement and physical activity.

	New Zealand	Australia
Physical distancing (>2m)	Yes	Yes
Self-isolation for >70 year olds and people with pre-existing health conditions, or Covid-19 symptoms or diagnosis	Yes	Yes
Exercise (e.g., walk, jog, and cycle etc.)	Two or more forms of exercise/day	Only one form of exercise/day
Only shopping for basic necessities (e.g., food/medicine)	Yes	Yes
Travel for specific medical needs	Yes	Yes
Essential travel for key workers only, everyone else works from home	Yes	Yes
Pubs/gyms/playgrounds/cinemas/restaurants/schools/places of worship closed	Yes	Yes

Note: Key workers included primary health care, supermarkets, pharmacies, food production including farming, delivery personnel, emergency services, businesses that support essential services.

A short survey collected demographic and physical activity information (International Physical Activity Questionnaire: Short Form [IPAQ-SF], Craig et al., 2003), along with doctors mental health (Depression, Anxiety and Stress Scale-42, DASS-42). The IPAQ was developed to use as a global tool to measure physical activity and the 9-item short form records the activity of four intensity levels including vigorous-intensity, moderate-intensity, walking, and sitting over the last 7 days (Craig et al., 2003). While accelerometer-derived physical activity measures are superior to questionnaires (Lee, Macfarlane, Lam, & Stewart, 2011), the design of this study did not allow for such monitoring. Using the IPAQ-SF on large populations is a validated tool to measure physical activity (Grimm, Swartz, Hart, Miller, & Strath, 2012). The DASS-42 is a commonly used self-report scale that assesses symptoms of depression, anxiety and stress (Lovibond & Lovibond, 1995). The 42-item questionnaire consists of 3 subscales (depression, anxiety and stress) and has been shown to have acceptable to excellent internal consistency and concurrent validity (Antony, Bieling, Cox, Enns, & Swinson, 1998).

2.1. Data Preparation

Data from the IPAQ-SF was coded and analysed using the recommended guidelines found on the IPAQ website (www.ipaq.ki.se). Using the IPAQ scoring system, the total number of days and minutes of physical activity were calculated for each participant in the areas of moderate and vigorous-intensity activity along with walking and sitting. In addition, we also calculated a physical activity continuous variable (MET-min.week^{-1}) according to the recommended guidelines. Each participant was also given a categorical score of "Low", "Moderate" or "High" according to their level of activity as outlined in the IPAQ guidelines (e.g., high; ≥ 7 days of any combination of walking, moderate-or-vigorous intensity activity achieving ≥ 3000 MET-min.week^{-1}; moderate, ≥ 5 days of any combination of walking, moderate-or-vigorous intensity activity achieving ≥ 600- 2999 MET-min.week^{-1}; low, achieving < 600 MET-min.week^{-1} of physical activity. A further categorical score of meeting physical activity guidelines (i.e., had a categorical score of moderate or high = active), or not (received a categorical score of low = inactive) was calculated.

2.2. Data Analysis

The dataset obtained from the Qualtrics website was downloaded as a Microsoft Excel spreadsheet and was initially transferred to the Statistical Analysis System v 9.4 (SAS Institute; Cary, NC, USA) for further analysis. The data was then visually checked for outliers and inaccurate data by investigating the distribution and probability plots. Means and standard deviations along with frequencies and percentages were calculated for the various dependent variables (physical activity, DASS-42). Independent t-tests were used to determine significant differences between groups (e.g., New Zealand versus Australia, active versus inactive). Spearman correlation coefficients were calculated to measures associations between DASS-42 scores and physical activity variables including sitting time. Additionally, nominal variables representing the proportion of participants (and subgroups) meeting physical activity thresholds were compared by categorical modelling using the PROC FREQ procedure in SAS. A type I error of 5% was chosen for declaration of statistical significance; precision of estimates was represented by the 95% confidence limits.

3. Results

3.1. Demographics

A total of 469 participants completed the survey, 43 contained incomplete responses, and these were removed, leaving 426 participants. This led to a 90.8% inclusion rate. The New Zealand sample comprised of more females (65%) than males (34%) (Table 2). The Australian respondents were evenly spread with 52% female and 46% male. The overall gender distribution was 49.5% female, 33.3% male and 15.6% unknown (did not complete this question). In both samples, Caucasians were the predominant ethnic group (70%), with Asian 6.6%, Indian 4.2%, Māori 2.1%, Aboriginal 0.2%, and Pasifika 0.7% also being represented. The average age was 47.2 ± 11.9 years (mean ± SD).

3.2. Physical Activity Levels

During the COVID-19 lockdown, 81% of participants in both countries met the recommended physical activity guidelines. Within this group, 50% of participants reported a high IPAQ-SF score. There were no differences in physical activity levels between countries or genders (Table 3). Sitting time was similar between participants from both countries, averaging 350 min (5.8 hours) per day overall.

3.3. DASS-42

Depression, anxiety and stress were similar in participants from both countries. The levels of stress and depression were higher than for anxiety in both samples. (Table 3).

3.4. DASS-42 and Physical Activity

Data from both countries combined, demonstrated statistically higher depression ($p = 0.006$), anxiety ($p = 0.008$) and stress ($p = 0.002$) scores in the inactive compared to the active participants (Table 4).

The Spearman correlation coefficients demonstrated small to moderate negative correlations between physical activity levels measured by MET-min.wk^{-1} and DASS-42 with females tending to have slightly stronger associations than males (Table 5). Although the correlations are relatively small the combined male and female data indicates that a lower physical activity level was associated with higher depression, anxiety, and stress. We also found small to moderate positive correlations between sitting time and DASS-42 scores. These associations tended to be stronger in males than females, and indicates increased depression, anxiety and stress with increased sitting time.

Table 2: Population characteristics of the study sample.

	New Zealand	Australia	Unknown	Total
Sample (n)	199	172	55	426
Sex (n, %)				
Male	64 (33.7%)	78 (45.8%)		142 (33.3%)
Female	123 (64.7%)	88 (51.8%		211 (49.5%)
Prefer not to say	3 (1.6%)	4 (2.4%)		7 (1.6%)
Unknown			66	66 (15.6%)
Age (mean ± SD)	47.2 ± 12.4	47.2 ± 11.2		47.2 ± 11.9
Age groups (n, %)				
18-29 years	13 (6.8%)	6 (3.5%)		19 (4.5%)
30-39 years	40 (21.0%)	40 (23.7%)		80 (18.8%)
40-49 years	56 (29.5%)	50 (29.6%)		106 (24.9%)
50-59 years	44 (23.2%)	46 (27.2%)		90 (21.1%)
60-69 years	30 (15.8%)	22 (13.0%)		52 (12.2%)
70-79 years	6 (3.2%)	5 (3.0%)		11 (2.6%)
80 + years	1 (0.5%)	0 (0.0%)		1 (0.2%)
Unknown			67	67 (15.7%)
Ethnicity (n, %)				
Caucasian	167 (83.9%)	131 (76.2%)		298 (70.0%)
Asian	14 (7.1%)	14 (8.1%)		28 (6.6%)
Indian	2 (1.0%)	16 (9.3%)		18 (4.2%)
Māori	8 (4.0%)	1 (0.6%)		9 (2.1%)
Aboriginal/Torres Strait Island	0 (0.0%)	1 (0.6%)		1 (0.2%)
Pacific Island	1 (0.5%)	2 (1.2%)		3 (0.7%)
Other	7 (3.5%)	7 (4.0%)		14 (3.3%)
Unknown^			55	55 (12.9%)

Note: ^Unknown were participants that completed the questionnaire but left some questions unanswered (e.g., 66 participants did not answer the gender question). Prefer not to say includes 1 non-binary individual.

Table 3: Physical Activity during the Covid-19 restrictions along with the DASS.

	New Zealand	Australia	Total
Met PA guidelines (n, %)			
Male and females	151 (80.7%)	136 (81.9%)	287 (81.3%)
Males only	56 (87.5%)	65 (83.3%)	121 (85.2%)
Females only	95 (77.2%)	71 (80.7%)	166 (78.7%)
Prefer not to say	2 (66.7%)	4 (100.0%)	6 (85.7%)
IPAQ-SF (mean ± SD)			
Total PA (MET-min.wk^{-1})	3081.6 ± 2920.7	2885.7 ± 3217.2	2943.6 ± 3009.7
Sitting time (min.d^{-1})	401.9 ± 235.2	362.2 ± 191.3	349.7 ± 231.9
IPAQ-SF Classifications (n, %)			
Low	39 (19.6%)	31 (18.0%)	80 (18.8%)
Moderate	60 (30.2%)	54 (31.4%)	133 (31.2%)
High	100 (50.2%)	87 (50.6%)	213 (50.0%)
DASS score (mean ± SD)			
Depression	6.1 ± 7.6	5.8 ± 8.2	6.0 ± 7.9
Anxiety	2.6 ± 3.8	2.8 ± 4.1	2.7 ± 4.0
Stress	9.2 ± 8.0	9.7 ± 8.4	9.4 ± 8.2

Note: No significant differences between sexes for Physical Activity (PA) guidelines. No significant differences between countries for guidelines. No significant different between countries for total PA or sitting time. No significant differences between countries for DASS scores.

Table 4: DASS score in the participants deemed active or inactive from the IPAQ criteria.

	Inactive (Not meeting PA guidelines)	Active (meet PA guidelines)	Mean difference between groups; 95% confidence limits
DASS score			
Depression	8.3 ± 9.1	5.4 ± 7.5	2.9; 2.0*
Anxiety	3.8 ± 4.2	2.5 ± 3.9	1.3; 1.0*
Stress	12.1 ± 9.1	8.8 ± 7.8	3.3; 2.1*

Note: Data are mean ± SD. *Statistically significant ($p < 0.05$) between the active and inactive groups.

Table 5: Correlation between physical activity, sitting time and DASS.

	Males	Females	Total
DASS score and physical activity $MET.min^{-1}.week^{-1}$			
Depression	-0.12	-0.21*	-0.19*
Anxiety	-0.12	-0.12	-0.13*
Stress	-0.08	-0.15	-0.15*
DASS score and sitting time			
Depression	0.16	0.12	0.15*
Anxiety	0.07	0.10	0.11*
Stress	0.24*	0.07	0.15*

Note: *Statistically significant ($p < 0.05$) correlations.

4. Discussion

The present study, to our knowledge is the first to investigate the effect of Covid-19 restriction on physical activity and mental health in medical doctors in New Zealand and Australia. It is well documented that doctors suffer from higher levels of mental health issues compared to the general population (Aiken, Clarke, Sloane, Sochalski, & Silber, 2002; Caplan, 1994) and the added challenges due to COVID-19 may exacerbate these conditions (Galbraith, Boyda, McFeeters, & Hassan, 2020).

The recruitment numbers of this study represent adequate participation of the medical fraternity. We were able to achieve a 90.8% completion rate and the population sampled was representative of the current age and gender mix in the medical cohort in the two countries. European doctors were more heavily represented and indigenous doctors were underrepresented in this survey (e.g., the distribution of Māori participants in this survey was 2.1% compared to 3.5% of doctors currently working in the area, while 0.8% of Pasifika were surveyed compared to 1.8% currently working as doctors (Ministry of Health, 2018)). There was significantly more female doctors surveyed (58.6%) (Table 2) and it is postulated this may be due to the increasing proportion of female doctors in Australia (Australian Institute of Health and Welfare, 2020) and New Zealand (Ministry of Health, 2018) in recent years. Another explanation for this could be the fact that female doctors are possibly more invested in their health and wellbeing and therefore were more committed to completing this survey.

It is well documented that depression, anxiety and stress are overrepresented in the medical profession even prior to the onset of COVID-19 (Feeney et al., 2016). Preliminary data from Faulkner et al. (2021) indicates that DASS-42 scores in the general population during the COVID-19 pandemic were approximately one-third of the scores reported by the medical doctors of this study. Given the increased workload and stress on medical doctors at this time, the increased DASS-42 scores represent a real increase in doctors' levels of depression, anxiety, and stress.

Approximately 81% of the male and female doctors participating in this study met the recommended physical activity levels during the lockdown. While we did not collect data on the change in physical activity from before-to-during the lockdown, we postulate (based on data from normal populations at this time (Faulkner et al., 2021; Meiring, Gusso, McCullough, & Bradnam, 2021)), that physical activity in doctors was likely to be reduced which was likely to negatively affect mental health, as has been indicated in other studies (Faulkner et al., 2021; Meiring et al., 2021).

Severe limitations on access to physical activity and increased mental health issues have been reported in many countries across the globe both in HCWs (Kang et al., 2020; Pappa et al., 2020; Rossi et al., 2020) and in the general population (Lesser & Nienhuis, 2020). The negative effect of the COVID-19 pandemic restrictions on mental health (depression, anxiety, and stress) was seen to be significantly higher in doctors who were physically inactive during this time as compared to their more physically active peers. Our study indicated that rates of depression, anxiety and stress were increased in the cohort that did not complete the required physical activity levels.

The reduction in levels of physical activity could be due to pandemic-associated restrictions limiting doctors to in-home or outdoor activities, but this can also be due to heightened stress and mental ill-health, resulting in increased fatigue and/or less attention to self-care.

In New Zealand, most family practitioners were tasked with providing COVID-19 testing and tracing services with little or no support from the central government, which is likely to have led to increased stress while trying to maintain regular patient care. The increased demands on doctors during this time probably led to more physical and mental fatigue resulting in less time available for physical activity.

Although an exact causation cannot be derived by this observational study, a lack of physical activity and increased boredom accompanied by increased weight gain and consumption of alcohol can be potential reasons for synergistic effects of reduced physical activity and increased mental illness (Fallon, 2020). A recent estimation by the Foundation of Alcohol Research and Education in Australia found increased sales and consumption of alcoholic beverages during the COVD-19 restrictions (Foundation for Alcohol Research & Education, 2020).

Sitting time (which is a measure of sedentariness), showed a small positive correlation with measures of depression, anxiety and stress (Table 5). It has been known for some time that inactivity is an independent risk factor for chronic disease (Fung et al., 2000; Jakes et al., 2003), but a lack of activity is also associated with lower mental health status (Mummery, Schofield, & Caperchione, 2004). We suggest that this association was exacerbated during COVID-19 lockdown when work pressures were increased on medical doctors. Such associations need to be highlighted as areas of concern in the medical fraternity and appropriate steps need to be taken to alleviate this stress by increasing the access to physical activity options in the workplace or at home.

We are unaware of any participants contracting COVID-19. The physical symptoms related to a COVID-19 infection have the potential to cause heightened stress and restrictions in physical activity and the inability to continue providing care, as seen in a study involving HCW's from major hospitals in India and Singapore (Chew et al., 2020). Research from previous pandemics (such as SARS 2003, MERS 2012 and Ebola) have shown that HCWs can experience a broad range of psychological morbidities that can endure for many months after an outbreak (Maunder et al., 2004). Furthermore, negative effects on mental health can be found in doctors irrespective of whether or not they worked in the front line with infected patients (Um, Kim, Lee, & Lee, 2017).

The current global pandemic has identified the need for doctors to develop strategies to cope under pressure. Most HCWs feel a strong obligation to continue working despite the dangers posed to their own health (Goulia, Mantas, Dimitroula, Mantis, & Hyphantis, 2010). Going forward, recognising that such a pandemic may occur again (or continue with a different COVID-19 variant), the authors recommend universities and professional colleges establish wellbeing strategies in the medical curriculum. It is well documented that HCWs especially medical doctors, find it difficult to disclose mental health issues with colleagues or seek professional help (Hassan, Ahmed, White, & Galbraith, 2009).

A plethora of global studies in the last 12 months have shown that physical activity levels have decreased, and sedentary behaviour increased during the COVID-19 pandemic lockdowns (Faulkner et al., 2021; Meiring et al., 2021; Stockwell et al., 2021). Decreases in physical activity have resulted in increased anxiety and depression (Di Corrado et al., 2020). The benefits of physical activity for both mental and physical wellbeing have been well established (Kohl 3rd et al., 2012). The current coronavirus pandemic is exacerbating physical inactivity and its associated problems. We propose that doctors and HCWs need to be at the forefront of the "exercise is medicine movement". There is a role for health boards to implement facilities and breaks to ensure that doctors are able to meet their recommended physical activity levels while at the workplace. It is critical that governments and health boards address the significance of the strain that is faced by doctors as a result of the pandemic and implement long term solutions.

One of the limitations of this study is that analyses did not specify between the medical sub-speciality doctors nor were differences between doctors working in public and private sectors investigated. Therefore, this study was unable to separate out those at higher risk of contracting COVID-19 to investigate whether the associations between mental health and physical activity were different in this group. Further, exact causation related to specific factors could not be derived from this cross-sectional, correlational study. Sub-group analyses of confounding factors such as pre-existing mental illness, private or public health care settings, socio-economic status and financial stress, lack of family or social support and ethnicity would be worthy research explorations in the future. Not only can these confounding variables have consequential impact on the mental health outcomes, but they may also be important to formulate preventative plans for doctors for future pandemics or subsequent waves of the same COVID-19 infections. Another limitation of the current study was that we were unable to investigate other causative factors that impair wellbeing such as poor sleep, high alcohol consumption and poor diet.

The SARS-COV2 virus outbreak led to a global pandemic in 2020 resulting in increased stressors on health systems worldwide which in turn led to greater demands on HCW. This study has found that doctors working during the COVID-19 pandemic lockdowns in New Zealand and Australia had high levels of depression, anxiety and stress. However, doctors that met the current physical activity guidelines showed significantly lower depression, anxiety and stress than doctors that did not meet the guidelines. Our data shows the importance physical activity has in maintaining wellbeing for doctors in the workplace. We suggest some simple measures such as ensuring access to regular breaks for exercise, along with better access to counselling could be initial starting points to improve doctor's response to increased work stress.

Conflict of Interest

The authors declare no conflict of interests.

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Moving in the margins: A qualitative study into the role of physical activity in marginalised communities

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ABSTRACT

Regular physical activity is essential in maintaining health and well-being. However, people in marginalised communities who experience financial insecurity or housing insecurity often face significant barriers to physical activity. Using a qualitative approach, 12 semi-structured one-to-one interviews were conducted with clients of a local charitable organisation who had been supported in undertaking physical activity. Interview transcript data was analysed using thematic analysis. The key theme that we identified was that physical activity support resulted in participants actively shaping their health and well-being in four key areas: mental, physical, social and behavioural health. These results are closely aligned with two established frameworks that describe well-being outcomes: Self-Determination Theory and Te Whare Tapa Whā (Māori Model of Health). This research highlights the significance of physical activity in improving the well-being of people in some marginalised communities, and the importance of localised organisations that facilitate these initiatives.

1. Introduction

It is well established that regular physical activity (PA) is important for health and well-being (World Health Organisation, 2020). While perceived by many of the general population as leisurely pursuit, PA is actually a crucial aspect of leading a healthy life that has been identified as being a significant contributor to positive mental, physical, and social health (World Health Organisation, 2020). As such, PA is effectively a human right (Messing et al., 2021) and PA-related facilities, goods and services should be accessible to marginalised communities (Tobin & Barrett, 2020).

However, in marginalised and vulnerable communities that are characterised by high financial insecurity and housing instability, opportunities for PA can be difficult to access. For example, financial and related barriers to PA are frequently reported in terms of price, lack of childcare, lack of time and unpredictable lifestyles (Dawes, Sanders, & Allen, 2019; Withall, Jago, & Fox, 2011). In addition, financial barriers to PA in marginalised populations are often compounded by concurrent and often chronic physical and mental health conditions (Gregg & Bedard, 2016).

Previous research has highlighted the potential benefits of PA for members of marginalised and vulnerable populations. For example, in a mixed methods study of homeless men in Canada, Gregg and Bedard (2016) found that the perceived benefits of PA included empowerment, social connection, transferable life skills, achieving a desired appearance, increased confidence and the opportunity to spend time outdoors and connect with nature. Also using a mixed methods approach, Withall et al. (2011) found that benefits such as social connection, increased confidence and enjoyment were the main motivators for members of a low socioeconomic population in the UK in continuing to undertake PA.

Such benefits of PA for marginalised and vulnerable populations can be achieved through initiatives that improve their accessibility to PA. For example, Dawes et al. (2019) discovered that homeless women in the UK who were provided with equipment such as running shoes and the opportunity to run in a group setting reported improvements in physical and mental health and well-being (e.g., fitness gains and pain reduction,

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increased confidence and positivity, reduced loneliness). Similarly, sporting events such as the Homeless World Cup – a sporting initiative in which homeless people represent their country in a football tournament - have been shown to promote social connection, increase confidence and self-esteem and result in reduced drug use, in addition to reducing societal stigma (Magee, 2011).

1.1. Frameworks of well-being outcomes

The outcomes of PA for marginalised communities can be seen from the perspectives of well-established frameworks that describe well-being. One such example is self-determination theory (SDT), which is a universal framework that describes the role of the social environment in fostering positive well-being outcomes and ongoing motivation for a given activity (Ryan & Deci, 2000). This theory posits that individuals have three basic psychological needs: competency, relatedness, and autonomy. Competency refers to feeling confident and capable in expressing oneself and being active about doing so; relatedness refers to having a sense of belonging within a community; and autonomy refers to the feeling of being in control of one's decisions and actions (Ryan & Deci, 2002). According to SDT, individual well-being is maximised when these psychological needs are met by the person's social environment.

In Aotearoa New Zealand, Māori are over-represented in statistics for low socio-economic status, homelessness (housing insecurity), and poor health (Amore, 2016; Reid, Taylor-Moore, & Varona, 2014). Therefore, an important framework through which we can understand well-being from the perspective of Māori is Mason Durie's influential Te Whare Tapa Whā model, which was originally developed to better reflect a Māori world view (Durie, 1985). This model depicts the wharenui (house), which represents overall health and well-being. The wharenui is supported by four pillars: taha tinana (physical), taha whānau (social), taha hinengaro (mental) and taha wairua (spiritual). Within this framework, optimal well-being is achieved when these four pillars are balanced. A number of studies in Aotearoa New Zealand have also conceptualised the benefits of physical activity and exercise programmes using the Te Whare Tapa Whā model. These studies indicate that physical activity contributes to improvements in physical, spiritual, mental and social health, thereby restoring balance to the wharenui for a wide variety of populations, including cancer survivors, pregnant women trying to quit smoking and people with Parkinson disease (Roberts et al., 2017; Mulligan et al., 2018; Matapo-Kolisko, 2021).

The SDT and Te Whare Tapa Whā frameworks are complementary. SDT focuses on the importance of the social context in fostering well-being, while Te Whare Tapa Whā recognises and responds to indigenous concepts of well-being. We would expect people receiving support to do PA to experience benefits related to well-being, and these benefits can be explored at individual, community, and population levels using the SDT and Te Whare Tapa Whā frameworks.

In Aotearoa New Zealand, some charitable organisations support PA opportunities for marginalised communities that are characterised by financial insecurity and/or housing insecurity. For example, Wellington City Mission is a charitable organisation based in Wellington that helps to reduce financial barriers to PA by providing clients with subsidised or free leisure club passes, memberships to recreational clubs, and sports equipment. However, the effects of such support for PA in marginalised communities have yet to be fully investigated in Aotearoa New Zealand. Therefore, the primary aim of this research project was to explore the outcomes that clients of Wellington City Mission clients have experienced as a result of support in undertaking PA from the organisation.

1.2. Research question

The primary research question was: What impact have physical activity subsidies had in terms of supporting the well-being of individuals in marginalised communities?

2. Methods

2.1. Study design

A qualitative methodology was used to obtain an in-depth insight into the experiences of members of the Wellington City Mission community in terms of the outcomes associated with supported PA opportunities. One-to-one interviews allowed the interviewer (EC) to build rapport with the participants and facilitate the participants in feeling safe and comfortable when discussing personal information. This study was approved by the University of Otago Ethics Committee (ref.: D21/328) and all participants provided written informed consent.

2.2. Participants

The participants for this study consisted of twelve clients of Wellington City Mission. The participants ranged in age from 30 to 64 with mean age of 47 years. Ethnicities included Māori (n = 2), Turkish (n = 1), Japanese (n = 1) and Pākehā (NZ European) (n = 1), with eight participants choosing not to disclose their ethnicity when asked. There were three female participants and nine male participants. All participants had received support from Wellington City Mission in undertaking PA in the form of leisure club passes, swimming passes, sports equipment or sports club memberships. Two participants had children or grandchildren in their care, seven participants disclosed they were currently in an unstable housing situation, and five participants had experience with self-diagnosed mental health conditions (including bipolar disorder, depression, anxiety, post-traumatic stress disorder, and bulimia). Pseudonyms were used during analysis and reporting (and throughout this article) in order to protect participants' anonymity.

2.3. Recruitment

Participants were recruited via a poster containing the study information, which was displayed at Tā Te Manawa (the Wellington City Mission Community Lounge). Social workers and staff at Wellington City Mission also helped with recruitment by providing clients with study information. The interviewer (EC) spent time at Tā Te Manawa getting to know the manuhiri (guests) and participants were also recruited this way. Participants were

offered a $20 grocery or petrol voucher as renumeration for participation.

2.4. Data collection

EC conducted semi-structured interviews onsite at Wellington City Mission from November 2021 to January 2022. Interviews followed a pre-determined interview guide, with questions divided into three main areas: barriers experienced by participants in accessing PA and how they had been supported in overcoming these barriers; the outcomes of participants' PA; and what participants would like support with to continue PA in the future. For the purpose of answering our research question, the outcomes of PA were the primary focus of the interview. The interview guide was inductive in nature – that is, no *a priori* model was presented to participants regarding potential PA outcomes, and participants were left to interpret outcomes according to their own perspectives. Participants were offered the opportunity to have a social worker present during the interview, an option taken by five participants. Interviews were digitally recorded and the transcribed verbatim using Temi, a secure online transcription program. We anticipated that we would require twelve participants, with the potential for more if data saturation was not achieved by this point (Guest et al., 2006). Following the interview with Participant 10, two of the research team (EC, MJ) undertook a preliminary analysis. Following the subsequent analysis of interviews with Participants 11 and 12 the research team decided data saturation had been achieved and recruitment ended.

2.5. Data analysis

Thematic Analysis (Braun & Clarke, 2006) was used to analyse the data. First, EC read through all the transcripts and identified quotes which were potentially relevant to the research questions. These quotes were then organised into a wide range of codes which were collated under the headings 'barriers to PA', 'facilitators of PA', 'outcomes of PA', 'praise for Wellington City Mission' and, 'the future'. These codes were discussed and refined by EC and MJ. Tables containing the codes and all the relevant quotes were then made by EC, allowing for overlap of quotes which were relevant to more than one code. EC and MJ then discussed how the codes could be arranged into themes and sub-themes and selected representative quotes for each sub-theme. The preliminary themes, sub-themes, quotes and codes were then shared with MH and PS and any discrepancies in analysis were discussed amongst the team until consensus was reached.

2.6. Member-checking

Member-checking was achieved by providing participants with a copy of the report. Participants were asked to respond within fourteen days if they had any concerns about the report, if they were not heard from it was assumed they were satisfied with our interpretation of the interview data. No participants responded.

2.7. Researcher self-reflection

In keeping with Thematic Analysis methodologies (Braun & Clarke, 2006), self-reflection was facilitated by notes made following each interview, and by discussion between the research team. This enabled the researchers to be made aware of their attitudes towards the outcomes of PA for marginalised communities and ensured that the influence of these attitudes on the process of analysis was minimised.

3. Results

3.1. Barriers

A summary of barriers is provided to contextualise the main study results. Participants reported key barriers to undertaking PA, of which accessibility was the most frequent. Other barriers included childcare obligations, mental and physical health conditions, and having to go through a clinical route to get support to do PA. These barriers and illustrative quotes can be seen in Table 1.

By helping their clients to overcome financial barriers in accessing PA, Wellington City Mission provided their clients the opportunity to actively and positively shape various aspects of their own health. These aspects included behavioural, mental, physical and social health; these interweaved and contributed to an overall improvement in health and well-being for the participants. A selection of these four key themes, sub-themes and illustrative quotes can be seen in Table 2, and a visual depiction of these themes can be seen in Figure 1.

3.2. Actively shaping mental health

This highlights the sub-theme of improvements in self-esteem and confidence, which fits into the theme of shaping mental health through PA. Eddie explains: "There's nothing like a bit of exercise to burn off some of the necessary worries and to feel good about your self-esteem". For Steven, improvements in self-esteem related to a healthier relationship with his body: "I don't hate seeing myself in a mirror…I genuinely would not go outside some days because I just didn't feel like being seen…but that's not stopping me anymore'.

Another sub-theme of mental health was the idea that PA can help with emotional regulation via the expression of emotions. Participants liked having access to different types of PA which allowed them to express a range of emotions, for example Tracy described how she would "relax in the spa if that what it is and just chill or go to squash if you're angry and smash the ball". Steven also gained emotional regulation skills through PA which he was able to use in other areas of his life, "Where I work, we can have some pretty unfavourable people I have to remove…I don't get so anxious or stressed anymore…I don't have that temptation to fight anymore".

A prominent sub-theme of shaping mental health through PA was stress reduction. For Tracy, a mother of four children, this was about having time to herself which she did not normally get: "These are the sort of things that I don't put first in my life, but to…have something for me has been awesome". Sam said that

Table 1: Participants' barriers to physical activity.

Barrier	Sub-theme	Illustrative quote
Accessibility	Financial	"When you don't have a surplus on your income… it's just one of those things you have to go without"
	Geographical	"I had no vehicle so I would have had to bus all the way…or walk into town and that would have been no good for me cos you know once my anxiety hits, I freak out and I've got to go home"
Pain	Psychological	"I definitely was struggling (to undertake PA) when I was more depressed"
	Physical	"My back inhibits me a lot"
Family obligations		"Especially to re-spark that thing in me (playing squash) that I haven't been able to do due to… me having four kids"
Convoluted routes to PA support		"Unless a person can convince your doctor of a disability certificate…that you have a medical reason to exercise… not many people know how to do that…and not many doctors allow that"

Table 2: Key themes, sub-themes and illustrative quotes for the benefits of physical activity for clients of Wellington City Mission.

Theme	Sub-theme	Illustrative quote
Behavioural	Lifestyle changes	"When you've got someone who's lost weight, quit smoking, wants to go back to work, their faculties all back and is inspired again to start working for herself, you've got a win"
	Improved behavioural choice	"It's (PA) lifted (me) up to the point where I've made other changes as well now…I bought myself a Nutribullet"
	Role modelling for tamariki (children)	"Not only for me, for my kids to see me doing something positive…you can't buy that"
Mental	Hedonic well-being	"I love the way I feel after exercise…the endorphins, serotonin, those ones that make you feel good…you actually start to crave it eh"
	Emotional regulation	"It's a good way to just process any like bad emotion that I've got going on"
	Improvements in self-esteem and confidence	"I don't hate seeing myself in a mirror…I genuinely would not go outside some days because I just didn't feel like being seen…but that's not stopping me anymore"
	Stress reduction	"Swimming is different. You're in your own little zone…puts your mind in a different space"
	Management of existing mental illness/addiction	"You just push yourself, 'right I'm going to the gym, I'm gonna do this'…and that sort of kick-starts you out of your depression"
Physical	Weight management	"I go through like binging and restricting cycles with my food…which I've managed to break out of...so now I'm like losing maybe half a kilo a week max…it feels sustainable and good"

	Improvements in fitness and strength	“Instead of walking once around the block, I could walk four times around because of the swimming and it increased my strength in the back…that’s the best bit actually”
	Managing an aging body	"I’m glad I’m still this active at fifty…when I was thirty I thought when you’re fifty it’s time to die you know…but I still feel like a young fella”
	Negotiating chronic physical conditions	“Walking down to the swimming pool on the concrete…it’s very painful, so when I get in the water it’s a relief…swimming has been a Godsend”
Social	Sense of community	"That’s (going to the gym) actually exercising that (connection with other people), um, which you don’t have so much when you’re on a long term, minimal income...because of that financial ceiling, you are separated from society...that’s what the pass is for”
	Spending quality time with whānau (family)	"They’re (children of the participant) absolutely happy... they love going to the pools, it's the thing that we can do together as a family, it’s our special treat time"
	Making new friends	“I know for myself, meeting my friend, it’s been good having someone else to talk to because I cut everyone out of my life that was in the drug scene”
	Breaking down perceived social barriers	“All of a sudden, you’re talking away with someone you don’t know, who has a completely different lifestyle…it takes you out of your world”
	Reciprocity	"Just to know that there’s other people out there that actually care about that side of things... where the price tag doesn’t mean anything it’s your well-being that means the most, then it makes you like, woah, there are these people care, then you can pay it forward"
	Family values	"I want to be in her (his daughter’s) life as long as I can...if I want to be in her life, I have to be healthy"

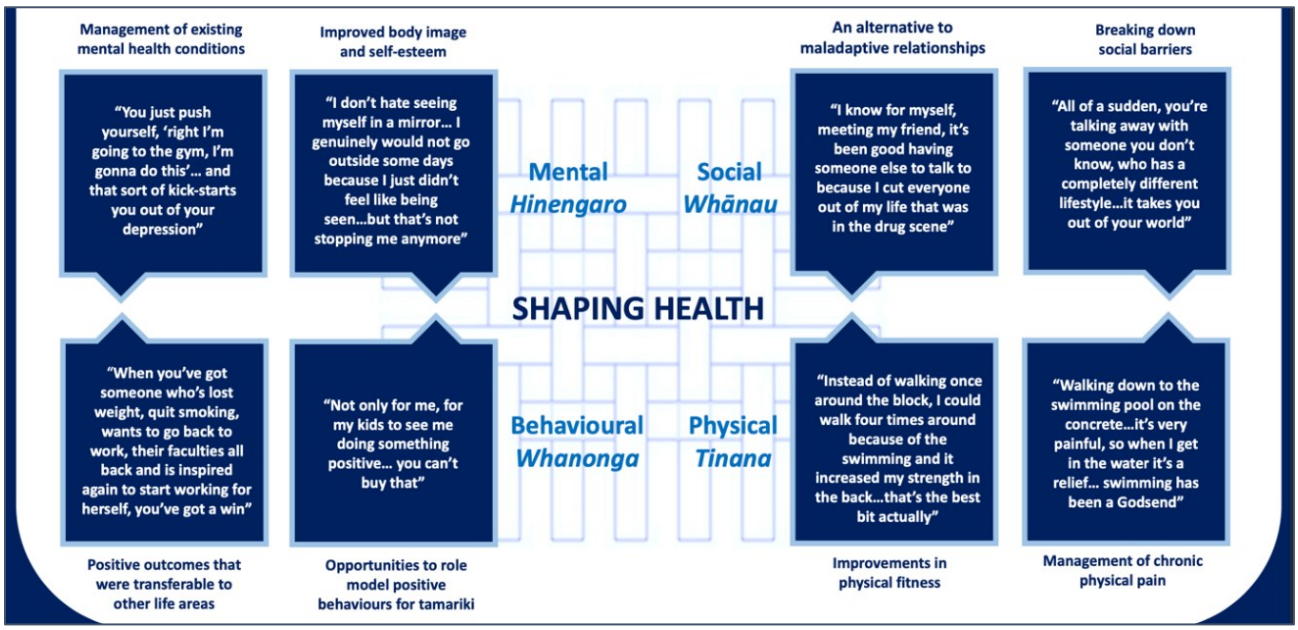

Figure 1: Key themes, sub-themes and illustrative quotes for the benefits of physical activity.

after exercising at the gym it feels like "a burden's taken off my shoulders", while Nathan stated that following an exercise session, he liked to sit in the sauna and get "rid of the baggage…release it with the vapour". Participants also found that PA helped to clear their mind. For Fiona, swimming helped her achieve this, "You're in your own little zone, the everyday traffic life's not happening around you…puts your mind in a different space, almost hypnotic…maybe it comes back to being in the womb".

3.3. Actively shaping physical health

PA also helped participants to positively shape their physical health in a variety of ways. A number of participants noticed improvements in their fitness and strength. Ethan noted his endurance improved: "I can ride to the top of the hill in one go without stopping, whereas a year ago there's no chance of doing that". Not only did improvements in fitness enable participants to be better at their preferred PA, but the benefits also extended to other PA they did in their everyday lives as Oliver explains: "Instead of walking once around the block, I could walk four times around because of the swimming and it increased my strength in the back…that's the best bit actually". For many participants, PA had contributed to weight loss which they were proud of. For example, Eddie stated: "I'm trying to lift my overall well-being and to keep just an aura of health and shed weight, and the more I shed the better I feel". For Steven, PA helped him to reach a place of stability with his eating and weight: "I go through binging and restricting cycles with my food…which I've managed to break out of…now I'm losing maybe half a kilo a week max…it feels sustainable and good".

Participants Eddie and Ethan highlighted a sub-theme of shaping physical health: using PA as a way to manage their bodies as they age, as Eddie explains "The better I can prepare myself (by doing PA) going into that age group…the better the outcome will be".

For many participants, PA was also a way for them to negotiate chronic physical conditions. Tom experienced diabetic neuropathy and swimming was a form of PA he could actually undertake, and indeed provided pain relief for him: "Walking down to the swimming pool on the concrete…it's very painful, so when I get in the water it's a relief…swimming has been a Godsend". Oliver had suffered back pain for years and the gym enabled him to strengthen other parts of his body to compensate for that pain: "When I first injured my back, I did a lot of weights and that strengthened my legs…because the back was always painful".

3.4. Actively shaping social health

Participants were able to positively shape their social health through PA. Access to PA fostered an increased sense of community. For some, this came from doing group sports where they had other people looking out for them as Steven explains: "The community aspect of it has been really important to me…you've got people holding you accountable and also checking in on you if you don't turn up". Nathan felt his low income prevented him from socialising and the leisure pass enabled him to overcome this barrier: "because of that financial ceiling, you are separated from society". Several participants expressed that they had met people who led different lives to their own, as highlighted by Fiona: "I've learned all about his culture… I would never have known if I hadn't met him at the pools". Eddie expressed empathy and understanding towards other people in transitional housing whom he had met through sports days organised by Wellington City Mission, "It's a lovely social thing to do…we're all in the same boat, we have our own stories, we have different stories and we shouldn't pre-judge people because they've got their own battles going on". Breaking down these social barriers not only enabled participants to learn about, and appreciate, other's lives but also to make new friends. For Fiona this was particularly important because she felt isolated after having removed herself from her prior, unhealthy social circle: "I know for myself, meeting my friend, it's been good having someone else to talk to because I cut everyone out of my life that was in the drug scene".

For two participants with children and grandchildren, the swimming passes and zoo passes were particularly valuable as they enabled them to spend quality active time as a family, something they couldn't achieve without financial support, as described by Fiona: "Just listening to them conversing and socialising and you know laughing their heads off…it was really cool". For Terry, it was not only important to share PA with his family, but to do PA himself to stay healthy so he could support his family "I want to be in her (his daughter's) life as long as I can…if I want to be in her life, I have to be healthy".

Many participants expressed gratitude for the opportunity to undertake PA. For some participants this helped to positively shape their social health by initiating reciprocity of kindness as Tracy explains: "Just to know that there's other people out there that actually care about that side of things, where the price tag doesn't mean anything it's your well-being that means the most, then it makes you like, woah, there are these people (that) care, then you can pay it forward".

3.5. Actively shaping health behaviours

PA contributed to healthy, holistic lifestyle changes participants made, as expressed by Tracy: "Having those positive things (squash and swimming) it brings everything else up to par…doing these things improves our whole lifestyle". A number of participants expressed that they were motivated to improve their lives instead of killing time until they found accommodation, as Eddie explains: "I want to get into a good sort of work, back into the rhythm of life again…so I'm utilising this time as much as I can to benefit myself in order to go forward".

Other participants found that PA helped them to quit unhealthy habits and developing healthy ones. Fiona credited swimming as helping her to quit smoking: "I did the (quit) smoking program, I tried everything, I could not quit these cigarettes…I never went 'I'm going to swim to quit smoking'...it just started happening as a natural process". Fiona had also made a number of other positive lifestyle changes since starting swimming which she was proud of, "When you've got someone who's lost weight, quit smoking, wants to go back to work and their faculties all back and is inspired again to start working for herself, you've got a win". Some participants had made healthy changes to their diet since starting PA, for example Eddie said he

now enjoyed making smoothies for breakfast: "It's (PA) lifted (me) up to the point where I've made other changes as well now…I actually bought myself a Nutribullet".

For those participants with children and grandchildren, them doing PA was a way for them to model making healthy behaviour choices, as Tracy explains: "It lets them know that hopefully when they get older, they're able to do these sorts of things (PA) as well…just having that foundation set in place for them". Tracy expressed that this was very important to her because she didn't have these kinds of positive things in her life when she was a child: "Just having that place to go you know like I was a kid that didn't have anywhere to go... it's huge…without the help that I've gotten, I wouldn't have been able to provide that for them".

3.6. Gratitude

One significant cross-cutting theme that emerged in the data was the theme of gratitude. Participants were grateful for the opportunity to do PA, as Tracy explains: "Just to get that other side of life you that I probably took for granted at a young age and now just being able to do it (PA) means so much". For another participant, Eddie, him making the most out of his pass was his way of expressing gratitude: "I feel happier because I knew it's something I had to do and it's been provided for me on a plate… I've got all the help that I need…that's the spark that motivates me because it's been gifted to me". By being given the opportunity to do PA, participants not only received benefits for their health, but also experienced what it is like to be shown kindness.

4. Discussion

The aim of this research was to explore the outcomes of doing PA for marginalised and vulnerable members of the Wellington community. We collected the stories of twelve members of this population who had been supported to undertake PA by receiving leisure club passes, sports club memberships, and sports equipment from Wellington City Mission. In supporting their clients to overcome financial barriers to accessing PA, Wellington City Mission provided their clients with the tools to positively and actively shape their health and well-being. Participants described improvements in aspects of their physical, social, mental and behavioural health and these contributed to an overall improvement in the well-being of participants.

Our results can be interpreted within the framework of Te Whare Tapa Whā, which describes how hauora (well-being) consists of four pillars - taha tinana (physical), taha whānau (social), taha hinengaro (mental) and taha wairua (spiritual) (Durie, 1985). Improvements in three of these four cornerstones were reported by participants. Taha tinana was strengthened by participants improving their management of their fitness, weight, injuries and illness. Taha whānau was strengthened by participants sharing PA with whānau (family) and new friends and feeling a sense of community. Taha hinengaro was strengthened by participants improving their self-esteem and management of mental health symptoms. Thus, by providing access to PA, Wellington City Mission enabled participants to strengthen these three pillars, which in turn contributed to an overall improved well-being.

The fourth pillar of Te Whare Tapa Whā – taha wairua – was not explicitly reported by participants. However, this is not to suggest that outcomes related to wairua were not experienced by participants, but it could be argued that spiritual aspects of health are conceptually more difficult to verbalise and discuss as opposed to physical, mental and social aspects of health.

From a motivational perspective, our results demonstrated how participants experienced feelings of self-determination and autonomy, as described within the framework of SDT. Within SDT, Deci and Ryan (1985) described how psychological well-being and ongoing motivation is maximised when an individual's social environment fosters social connection and autonomy. In the current study participants expressed that their three psychological needs (competency, relatedness, autonomy) were supported in the context of PA. PA improved participants' relatedness by facilitating new friendships and quality time with whānau (family) and breaking down social barriers. Participants reported improved confidence, fitness and management of their physical and mental health conditions, all of which contribute to increased perceived competency. PA encouraged autonomy within participants by allowing them to take control of their health, make healthy behavioural choices and make the most of the situation they were in. Wellington City Mission facilitated clients' autonomy as they were not instructing their clients about what to do for their health, but rather provided them with the opportunity to improve their health in ways that were meaningful to them and that were characterised by choice. Hence, participants felt a sense of achievement and autonomy at having undertook PA, and reaped the benefits that come with PA. As an organisation, Wellington City Mission supported the psychological needs of their clients by providing them with access to PA. With these needs supported, members of marginalised communities can be empowered and motivated to continue to do PA, and make and maintain other healthy life choices, contributing to an overall improved state of well-being.

4.1. Limitations and strengths

A limitation of this study was that the participants were self-selecting. We did not interview anyone who had negatives experiences with PA and/or Wellington City Mission, and as such we must acknowledge the potential for positive-experience bias in this study.

With regards to study strength, to our knowledge this study is the first to explore the outcomes resulting from PA support for people in marginalised and vulnerable communities within Aotearoa New Zealand. Therefore, the study offered a population that is often unheard the opportunity to share their voice, thereby providing an important insight into the lives of people in these communities and how we can best support them in improving and maintaining their health through PA.

4.2. Future research

Quantitative data for the effects of PA subsidies might be used to complement the rich qualitative data obtained here, in the form of surveys or intervention. Questionnaires exist that align with the frameworks described here. For example, in the framework of SDT, general motivation questionnaires and those specifically in the context of PA exist (Behavioural Regulation for Exercise;

Markland & Tobin, 2010), as do questionnaires that assess perceptions of psychological need support (Healthcare Climate Questionnaire; Williams & Deci, 2001) and satisfaction (PNSE-PA; Gunnell et al., 2012). Likewise, tools are available that can be used to quantify Māori well-being across the domains of Te Whare Tapa Whā (Mason & Kingi, 2000).

It would be valuable to explore the ongoing barriers that members of this population face in accessing PA. As demonstrated in this article, Wellington City Mission has provided support to overcome the major barrier of financial accessibility, however other barriers may still exist for participants such as family obligations and geographical accessibility. Investigating these ongoing barriers would add to the value of the work done here, enabling community services and organisations to further support these people in maintaining healthy behaviours.

Further, it would be useful to ascertain the cost-effectiveness of providing PA subsidies to marginalised communities. For example, researchers have used frameworks such as the human capital model (HCM) to explain how PA can be a platform for societal and individual gains across capitals relating to physical, mental, social and – in some cases – financial capital. At present, funding for such subsidies is an ongoing issue in the not-for-profit sector. Considering the potential for increased capital supported by such programmes, providing an argument for continuous funding would be of great benefit to funders, organisations, and beneficiaries alike.

5. Conclusion

Our findings suggest that providing marginalised communities with opportunities to do PA facilitates them in positively and actively shaping their health and well-being and highlights the importance of providing support for PA in the community. This is important for community organisations such as Wellington City Mission in terms of seeking ongoing funding, which can be strengthened in future research by incorporating quantifiable cost-effectiveness analyses. The research also highlights the importance of local organisations as local champions who are key in providing the practical, financial and emotional support that their clients require in order to do PA. Importantly, the study gave members of marginalised and vulnerable communities a voice; by expressing their thoughts and needs, the research has also supported them in further shaping their health in the hope that Wellington City Mission and other services will respond accordingly. Overall, this study demonstrates the multi-faceted benefits that PA can provide and reminds us why PA is considered to be a human right and crucial to leading a healthy life.

Conflict of Interest

The authors declare no conflict of interests.

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Blood monitoring in the English Premier League: Effect of curcumin supplementation on blood biomarkers of recovery

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ABSTRACT

Reducing inflammation during periods of frequent match play may be an important objective to promote player recovery and protect player health. The authors aimed to investigate the effect of curcumin supplementation on biomarkers of recovery in response to weekly match play during an English Premier League (EPL) season. We conducted a longitudinal analysis of 18 EPL games during the 2019 – 2020 season (n = 22), and used an interrupted time-series design to analyse the effect of curcumin supplementation on biomarkers of inflammation and pro-oxidant status. Participants consumed 2 × 500 mg capsules (Elite Opti-Turmeric, Healthspan, Ltd) for a total dose of 1000 mg of curcumin (as recommended by the manufacturer), the morning of game day -2 (GD-2), game day -1 (GD-1) and immediately post-game during each supplementation period. Relationships between biomarkers and co-variates were examined using linear mixed effects models. No significant effect was found for the intervention on C-reactive protein (CRP) responses. No significant relationships were observed for all other explanatory variables on CRP responses. We found a significant association between hydroperoxides (HPX) responses and time (0.005 mmol/L H_2O_2; $p = 0.020$). No significant effect was found for the intervention on HPX responses. No significant relationships were observed for all other explanatory variables and HPX. We report that curcumin ingestion at the dose and protocol prescribed is not effective, at least at a group level, for attenuating biomarker responses within the applied setting of professional soccer.

1. Introduction

Soccer match play is characterized by many high intensity episodes of physical stress, inducing skeletal muscle fibre damage, and predisposing players to recurrent episodes of acute inflammation (Ispirlidis et al., 2008). Acute inflammation is a vital protective process, acting to clear damaged tissue and promote repair, however, overwhelming inflammation can result in secondary damage and promote maladaptive tissue remodelling (Markworth et al., 2016). During periods of frequent match play,

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the recovery between successive games may not be adequate for the restoration of normal homeostasis and the resolution of the inflammatory response (Mohr et al., 2016), potentially leading to the development of chronic low-grade inflammation. Reducing inflammation during periods of frequent match play may therefore be an important objective for sports science and medicine staff in order to protect player health and recovery. Long-term supplementation with anti-inflammatory compounds is not recommended (Owens et al., 2019). However, when adaptation is inconsequential, for instance, during periods of heavy workload whilst 'in-season', or during periods of fixture congestion when the ability to recover in sufficient time is compromised, nutritional supplementation may be beneficial in aiding the timely recovery of the player. Furthermore, if we know that an inflammatory episode/insult will occur by virtue of competition, pre-competition acceleration of inflammation resolution via targeted nutritional supplementation may represent a practical approach for preventing the development of low-grade inflammation and promoting the timely recovery of the elite soccer player in-season.

Curcumin is a component of the spice turmeric and is often used to reduce exercise-induced inflammation (Heaton et al., 2017) due to its potential antioxidant and anti-inflammatory properties (Fernández-Lázaro et al., 2020). Moreover, positive effects on inflammatory markers have been observed when consumed prior to exercise in physically active individuals (McFarlin et al., 2016; Szymanksi et al., 2018; Tanabe et al., 2019). However, data in elite athletes are generally absent from the literature, with only one study conducted to date (Delecroix et al., 2017). Delecroix et al. (2017) observed that curcumin supplementation taken before and after exercise attenuated some (i.e., reduction in sprint mean power output was moderately lower in the experimental condition), but not all aspects of muscle damage, in a group of elite rugby players. Heaton et al. (2017) suggest that supplementation with oral curcumin may be beneficial for athletes participating in high-intensity exercise with a significant eccentric load, and its utility warrants investigation in elite soccer players. To the knowledge of the authors, research investigating the efficacy of an anti-oxidant/anti-inflammatory intervention in the English Premier League (EPL) are absent from the literature. Therefore, this study was designed to investigate the efficacy of curcumin supplementation on biomarkers of recovery during an EPL season. We hypothesized that biomarker responses could be altered by accelerating the resolution of inflammation using curcumin supplementation prior to competition.

2. Methods

2.1. Participants

Twenty-two players (age = 25 years, *SD* = 3 years, height = 182 cm, *SD* = 8 cm, weight = 75 kg, *SD* = 6 kg, body mass index (BMI) = 23, *SD* = 2) were recruited to participate from the first team of an EPL club. Ethical approval was obtained from the University of Galway research ethics committee and written informed consent was provided by all participants.

2.2. Design overview

We conducted a longitudinal analysis of 18 English FA Premier League games during the 2019 – 2020 season. We used an interrupted time-series design to analyse the effect of curcumin supplementation on biomarkers of recovery. Following a seven-game control period (i.e., Control 1; August/September), participants completed a four-game supplementation block (i.e., Case 1; September/October), followed by a second control period of two games (i.e., Control 2; November) and another supplementation block of five games (i.e., Case 2; November/December).

Training was prescribed by coaching staff and was deliberately not influenced by the study design or the research personnel. The athletes training load varied in intensity and volume depending on factors including but not limited to the following: player status (starter/bench player), time of season, upcoming games, injuries and illnesses. Match load data (volume, intensity, minutes) were collected and recorded for each game. As appropriate, players were classified as injured and ill by the medical staff. Only fit, healthy and training players were included in the experimental trial.

2.3. Blood biomarkers

Blood biomarker data were collected twice weekly (pre- and post-game) at the same time of day and included the following: high sensitivity C-Reactive Protein (CRP) and plasma hydroperoxides (HPX) via point-of-care blood tests. Over the course of the first half of the competitive season (August to December), repeated measurements of CRP and HPX were taken from these players before and after each of 18 games. Testing was carried out between 9 AM and 11 AM, with pre-game measurements taken on game day -1 (GD-1). The timing of the post-game measurements were dependent on the schedule prescribed by the coaching staff, and were taken on either game day +1 (GD+1), game day +2 (GD+2), game day +3 (GD+3), game day +4 (GD+4) or a combination thereof. Players were asked to report for testing in a fasted and hydrated state, where players reported not being fasted, this was noted and factored into the analysis. Inflammation was immediately measured with an immunoturbidimetric high sensitivity CRP assay (Cube-S point of care analyzer; Eurolyser Diagnostica GmbH, Salzburg, Austria) using a 20 uL ethylenediaminetetraacetic acid capillary tube. This photometric measurement of CRP is based on an antigen-antibody reaction between antibodies to human C-reactive protein bound to polystyrene particles and C-reactive protein present in the sample. All the biochemistry is contained within the test cartridges supplied by the manufacturer. The manufacturer reports a coefficient of variation for the assay of 2.8% for whole blood with a correlation coefficient R^2 of 0.951 against a clinical laboratory gold standard. The measurement range of the analyzer is 0.5 – 20.0 mg/L.

Pro-oxidant status was determined by measuring biological footprints of oxidative damage downstream of the site of reactive oxygen species production, using the Free Oxygen Radical Test calorimetric assay, an indirect measure of reactive intermediary by products of in vivo lipid, protein, and nucleic acid oxidation (plasma hydroperoxides). Whole-blood capillary samples (20 uL

for FORT) were taken from the earlobe in heparinized capillary tubes. These were mixed immediately with reagent, centrifuged at 5000 r·min^{-1} (2000 g) for 1 min, and analyzed according to the manufacturer's instructions, using a Callegari analyzer (Callegari SpA, Catellani Group, Parma, Italy) at 37 °C, with absorbance set at a wavelength of 505 nm for the calculation of FORT. Lewis et al. (2016) previously published in detail the methodology for the FORT assay. The manufacturer of the assays reports a coefficient of variation < 5% for FORT, and Lewis et al. (2016) have reported a coefficient of variation of 3.9%.

2.4. Match load assessment

Games were analysed during the 2019 – 2020 season, using a multi-camera computerised tracking system (Second Spectrum Inc, CA, USA). Game minutes, total distance and high intensity running distance (defined as distance covered at > 21 km/h) were recorded each game via cameras positioned in each of the stadiums and were analysed using match-analysis software (Second Spectrum Inc, CA, USA) to produce a single data set of each player's activity during a match.

2.5. Dietary supplementation

The dosing strategy selected (i.e., the timing, length and dose) was based upon a number of factors, including previous research (McFarlin et al., 2016; Szymanksi et al., 2018; Tanabe et al., 2019), the manufacturer recommendations and considerations regarding player compliance. Supplementation was initiated two days prior to each game. Participants consumed 2 × 500 mg capsules (Elite Opti-Turmeric, Healthspan, Ltd) for a total daily dose of 1000 mg of curcumin (as recommended by the manufacturer), the morning of game day -2 (GD-2), game day -1 (GD-1) and immediately post-game during each supplementation period. Each capsule contained: NovaSOL® curcumin 500 mg), vitamin C (20 mg). Participants maintained their habitual diet routine throughout each supplementation period. Supplement adherence was monitored via verbal confirmation by the same research personnel. To ensure compliance, the supplement was given only during the supplementation block, and on the days specified (GD-2, GD-1, Game Day). Where players reported non-compliance, this was noted and factored into the analysis. Subject non-compliance was broadly defined as subjects that did not adhere to the study protocol (i.e., missed supplement doses, missed testing appointments).

2.6. Statistical analysis

Summary statistics were calculated for each response variable and for the high intensity running covariate by testing time (Pre-/Post-) and stage (Control or Case). The stage variable was coded as a factor (with 4 levels) to account for the interrupted time series study design used (i.e., control / case / control / case). Linear mixed models were used to estimate the effect of the intervention on each response variable while controlling for stage, testing time, the number of days post-game where the post measurement was taken (i.e., GD+1, GD+2, GD+3, GD+4) and the amount of high intensity running recorded in the game in question. In order to account for the hierarchical structure in the design random effects were included for players, games and stage in order to account for the correlation within players over time, and for players within games and stages. The analysis excluded goalkeepers. Candidate models that were considered a-priori included models with an interaction term to adjust for potential differences in the mean response at the pre-testing time in each stage, models that included distance as an additional covariate and models using the gamma distribution to account for the strictly positive responses. All analyses were performed with the use of R (www.r-project.org, a language and environment for statistical computing software). A p value of less than 0.05 was considered to indicate statistical significance.

3. Results

A total of 22 athletes completed the study. Summary statistics for HPX and CRP responses by stage are detailed in Table 1. The effect of explanatory variables on CRP responses are detailed in Table 2. No significant effect was found for the intervention on CRP responses (Figure 1A). No significant effects were observed for all other explanatory variables on CRP responses. The effect of explanatory variables on HPX responses are detailed in Table 3. We found a significant association between HPX responses and time (0.005 mmol/L H_2O_2; $p = 0.020$). HPX responses were lower compared with measures taken at GD-1 during Case 1 (-0.18 mmol/L H_2O_2; $p = 0.057$), and higher at Control 2 (0.26 mmol/L H_2O_2; $p = 0.055$), albeit of borderline significance (Figure 1B). No significant relationships were observed for all other explanatory variables and HPX.

4. Discussion

The primary aim of this study was to assess the efficacy of an acute protective protocol (curcumin supplementation) on blood biomarkers of inflammation and pro-oxidant status during the in-season competitive phase of the EPL. The principal findings were that curcumin ingestion had no significant effect on CRP, and had borderline significant effects on HPX responses ($p = 0.057$). However, the magnitude of this change (-0.18 mmol/L H_2O_2) does not appear to be physiologically relevant, based on the previously published critical difference value for this assay (Lewis et al., 2016), suggesting that at a group level curcumin ingestion using the dose and protocol prescribed may not be effective for attenuating inflammation and pro-oxidant status within the setting of elite professional soccer. To our knowledge, this is the first study to investigate the efficacy of a nutritional intervention aimed at reducing blood biomarkers of recovery in professional soccer players competing in the EPL.

We report that HPX levels significantly increase within-season in apparently healthy players and that curcumin ingestion at the dose prescribed is not effective for attenuating biomarker responses in elite soccer players. Curcumin has been reported to downregulate the transcriptional activity of nuclear factor-kappa B (NF-kB), a key regulator of the inflammatory response, and upregulate nuclear factor erythroid 2 related factor 2 (Nrf2), the 'master regulator' of antioxidant enzymes (Sahin et al., 2016). Therefore, by simultaneously blocking the proinflammatory response and activating endogenous anti-oxidants, curcumin ingestion may act to control the regulation of inflammation during

Table 1: Summary Statistics for CRP (mg/L), HPX (mmol/L H_2O_2) and THIR (m) by Study Stage and Testing Time.

Stage	**Control 1 (August/September)**		**Case 1 (September/October)**		**Control 2 (November)**		**Case 2 (November/December)**	
	Pre (n = 87)	Post (n = 59)	Pre (n = 55)	Post (n = 41)	Pre (n = 33)	Post (n = 7)	Pre (n = 72)	Post (n = 45)
CRP								
Mean (SD)	1.62 (1.52)	2.15 (1.60)	1.48 (0.92)	1.91 (1.30)	1.49 (0.98)	2.72 (1.40)	1.50 (0.92)	2.21 (1.42)
Median	0.98	1.25	1.04	1.44	1.07	3.10	1.06	1.65
[Min, Max]	[0.76, 8.89]	[0.80, 7.75]	[0.81, 5.21]	[0.77, 7.22]	[0.74, 4.64]	[0.94, 4.10]	[0.79, 4.73]	[0.91, 7.48]
HPX								
Mean (SD)	1.55 (0.31)	1.64 (0.29)	1.75 (0.37)	1.74 (0.38)	1.67 (0.34)	1.95 (0.34)	1.79 (0.46)	1.78 (0.37)
Median	1.54	1.60	1.70	1.70	1.63	1.94	1.71	1.73
[Min, Max]	[1.22, 2.61]	[1.22, 2.46]	[1.22, 2.68]	[1.26, 3.11]	[1.22, 2.68]	[1.50, 2.47]	[1.22, 3.52]	[1.22, 2.46]
THIR								
Mean (SD)	446 (207)	454 (217)	391 (233)	473 (194)	446 (331)	468 (369)	388 (199)	415 (200)
Median	477	450	479	525	473	456	420	409
[Min, Max]	[49.0, 920]	[66.3, 920]	[14.6, 713]	[38.1, 713]	[7.83, 1100]	[7.83, 970]	[10.2, 822]	[17.2, 822]

Note: n**,** number of participants; SD, Standard Deviation; Min, Minimum; Max, Maximum; CRP, C-reactive protein; HPX, hydroperoxides; THIR, total high intensity running

Table 2: The estimated effect of explanatory variables on C-reactive protein (CRP) (mg/L) responses adjusted for the effect of game and subject by fitting linear mixed effects models.

Explanatory Variable	**Estimate**	**Standard Error**	***p***
Pre- (vs Post-) game	-0.860	1.132	0.453
Stage (Case 1)[a]	-0.380	0.564	0.512
Stage (Control 2)[a]	-0.299	0.734	0.691
Stage (Case 2)[a]	-0.671	0.941	0.491
GD +1days[b]	2.021	1.135	0.084
GD +2days[b]	1.147	1.132	0.319
GD +3days[b]	1.229	1.197	0.311
Time (Days)	0.010	0.009	0.311
THIR (m)	0.000	0.000	0.276

Note: [a]in comparison to Control 1; [b]in comparison to Game Day (GD)+4; THIR, Total high intensity running; GD, Game Day

Table 3: The estimated effect of explanatory variables on hydroperoxides (HPX) (mmol/L H_2O_2) responses adjusted for the effect of game and subject by fitting linear mixed effects models.

Explanatory Variable	**Estimate**	**Standard Error**	***p***
Pre- (vs Post-) game	0.095	0.119	0.426
Stage (Case 1)[a]	0.000	0.119	0.999
Stage (Control 2)[a]	-0.277	0.153	0.089
Stage (Case 2)[a]	-0.272	0.196	0.187
Time (Days)	0.005	0.002	**0.020**
THIR (m)	-0.000	0.000	0.613
Post-Test Day[b]	-0.016	0.004	0.721
Post- (vs Pre-): Stage (Case 1)[a]	-0.181	0.095	0.057
Post- (vs Pre-): Stage (Control 2)[a]	0.255	0.132	0.055
Post- (vs Pre-): Stage (Case 2)[a]	-0.077	0.007	0.288

Note: [a]in comparison to Control 1; [b]in comparison to Game Day (GD)+1; THIR**,** Total high intensity running*;* significant effects ($p < 0.05$) are displayed in bold

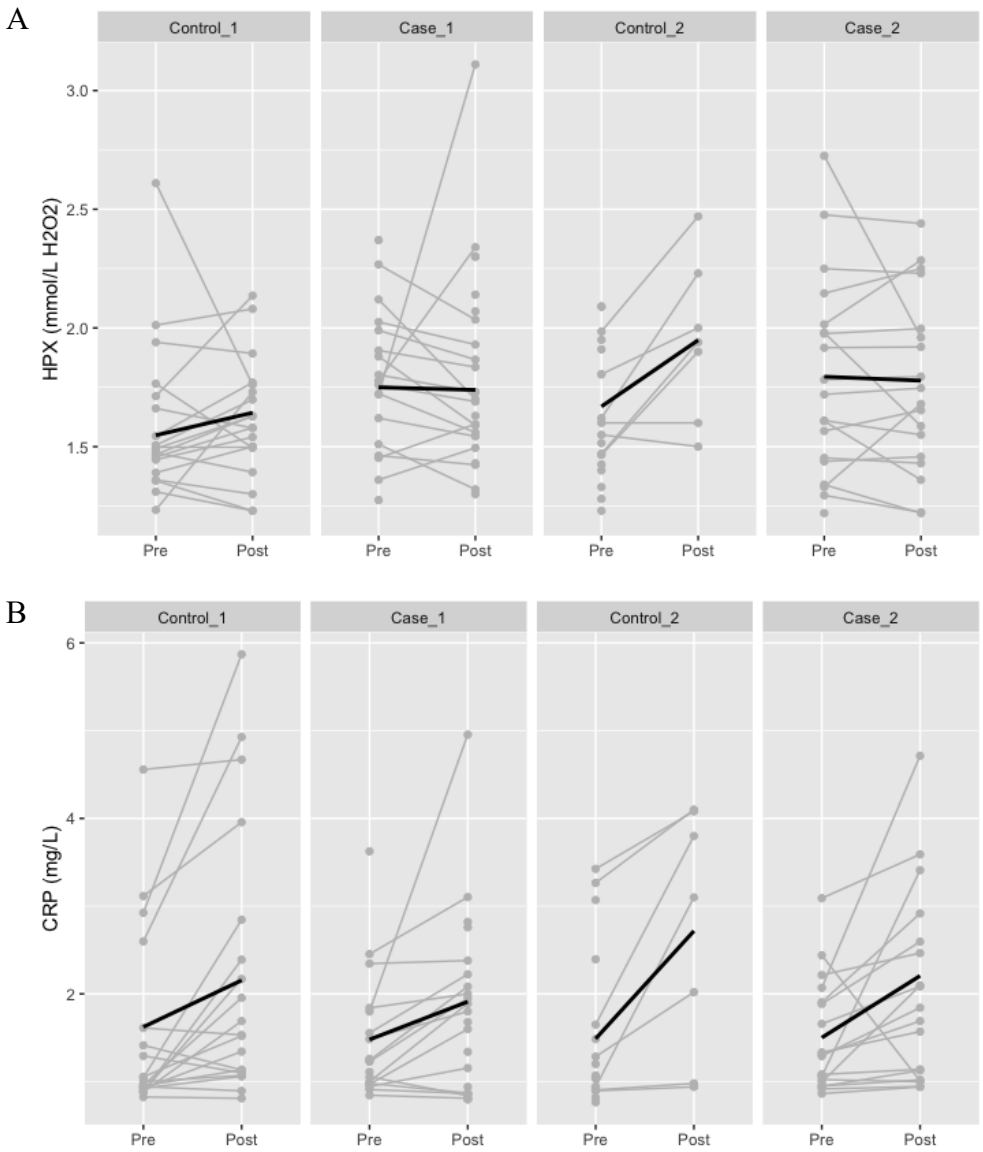

Figure 1: (A) Plots of players average C-Reactive Protein (CRP) (mg/L) trajectory over stage. (B) Plots of players average hydroperoxides (HPX) (mmol/L H_2O_2) trajectory over stage. Black lines represent group mean, grey lines represent player averages. Stages: Control_1 (August/September), Case_1 (September/October), Control_2 (November), Case_2 (November/December).

periods of high demand in the elite soccer player. However, in the current study, we report no significant differences between conditions for mean CRP values (Figure 1A). Indeed, reports are inconsistent with regards to exercise induced inflammation in the literature (Heaton et al., 2017; Suhett et al., 2020). In agreement with our findings, Drobnic et al. (2014) (400 mg daily dose for 48 hours prior to and 24 hours after a downhill running test in moderately active males) and Sciberras et al. (2015) (500 mg daily dose for 72 hours and immediately prior to a 2 hour cycling test in recreationally active males) have shown that whilst post-exercise increases in markers of inflammation have tended to be lower in curcumin treatment groups, significant reductions in inflammation with curcumin supplementation are lacking. In contrast, we observed reductions in mean HPX levels during the Case 1 phase (Figure 1B), albeit of borderline significance, suggesting that curcumin supplementation may attenuate exercise induced oxidative stress, a finding which is corroborated by previous research (Chilelli et al., 2016; Takahashi et al., 2013). However, when we consider the magnitude of this change (Table 3), physiological relevance appears questionable based on the previously published critical difference value for this assay (Lewis et al., 2016). The discrepancy between our findings and previous literature demonstrating statistically significant changes may be due to a combination of factors including the training and

dietary status of the population investigated, the biomarker assays measured and timing of the draw, and several limitations associated with the current study.

To the authors knowledge, this is the first study investigating the utility of curcumin supplementation in elite soccer players. Indeed, given the recognised differences in inflammatory responses between athletes and non-athletes (Gokhale et al., 2007; Handzlik et al., 2013), caution is necessary when extrapolating findings from previous research investigating the utility of curcumin in non-athletes to the professional soccer player. Evidence suggests that professional soccer players upregulate anti-oxidant enzymes during a season (Silva et al., 2014), thus potentially protecting well recovered players from excessive oxidative damage during subsequent competitions and training sessions. It is plausible that this upregulation may be sufficient to limit excessive inflammatory mediator production and therefore elite soccer players may have less need to use anti-oxidant supplements than non-athletes, especially when athletes may be consuming high polyphenolic diets. Indeed, focusing on a well-balanced diet including fruits and vegetables to counteract inflammation and oxidative stress may be more appropriate for the elite soccer player than supplementing with individual antioxidants/anti-inflammatory compounds, as there seems to be no evidence at this time to suggest that consumption of fruits and vegetables blunts exercise-induced adaptations (Heaton et al., 2017). Furthermore, human studies have shown that the intake of fruits and vegetables is associated with a decrease in the levels of systemic inflammatory markers, such as Interleukin (IL)-4, IL-6, IL-8, IL-13, Tumor Necrosis Factor-alpha (TNF-α) and CRP (Sureda et al., 2014) and increases in anti-inflammatory cytokines in well trained athletes (McAnulty et al., 2011).

The wide heterogeneity in CRP (Figure 1A) and HPX responses (Figure 1B) may also provide important clues about why the study results are inconsistent. Indeed, studies have shown that the efficacy of antioxidants is affected by inter-individual variability in redox state, which is dependant, among other factors, on the training and nutritional status of the athlete (Kawamura et al., 2018). Recent reports have recognised the importance of identifying and correcting redox deficiencies in athletes which may occur as a result of low fruit and vegetable intake (Pedlar et al., 2019; Plunkett et al., 2010; Watson et al., 2005). Plunkett et al. (2010) observed increased resting and exercise induced inflammation alongside increased RPE in endurance trained males in response to a two week dietary anti-oxidant restriction. Moreover, emerging evidence suggests that antioxidant supplements improve performance and oxidative stress only when administered to deficient individuals (Margaritelis et al., 2020). Therefore, the optimal intervention approach should involve the individualized examination of redox and inflammation status in athletes. This would allow for the identification of responsive phenotypes and the detection of meaningful physiological changes in individual data, by constructing individualized adaptive reference ranges (Roshan et al., 2021), resulting in the administration of the appropriate antioxidant supplementation at the appropriate time. Future studies should look to implement this targeted approach in elite sport.

The lack of significant changes in biomarker responses may also be explained by the assays measured in the current study. Higher concentrations of individual antioxidant enzymes as opposed to total anti-oxidant capacity have been found in rodents following curcumin supplementation (Avci et al., 2012), suggesting that curcumin's anti-inflammatory effects may potentially be tissue and/or enzyme specific (Basham et al., 2020). Furthermore, despite observing no significant reduction in serum levels of IL-6, McFarlin et al. (2016) reported a 25% decrease in circulating levels of the inflammatory cytokines TNF-α and IL-8 following muscle damaging exercise in a group of healthy participants. Thus, the lack of measurements of a wider range of inflammatory biomarkers and anti-oxidant enzymes could potentially be a limiting factor in the current study.

For practical reasons (i.e., financial and time constraints), we did not measure anti-oxidant status, thus, we potentially missed capturing the impact of curcumin on the players' plasma anti-oxidant capacity. Similarly, we did not assess whether curcumin's serum concentration had sufficiently increased after the supplementation regimen so as to produce biological effects (Suhett et al., 2020). Considering the field-based nature of the present study, obvious limitations include the inability to blind the players and staff to the supplementation regimen and control the players' dietary intake. However, the use of control versus intervention groups is generally un-feasible at the elite level as only a single population benefits from the intervention (Bongiovanni et al., 2020; Carling et al., 2018), and restricting an athlete of important dietary nutrients during a competitive season is counter-intuitive in a high performance environment if the goal is to conduct applied research. Indeed, Bongiovanni et al. (2020) suggest that applied research should replicate how athletes actually utilize supplements in a real-world scenario in order to inform practice, and thus, the nature of the study (i.e., highly-trained EPL players in a 'real-world' setting) strengthens the ecological validity and novelty of our data. The use of an interrupted time series design may therefore be considered novel, however, it is also possible that the training status and workload (e.g., THIR) of the athlete during the different stages of the intervention may have influenced the regulation of inflammation to a greater extent than the supplementation regimen.

Athlete belief is another important consideration in the application of an intervention (Halson et al., 2013; Howatson et al., 2016). Failure to capture the athletes perception of the supplementation regimen and whether or not they felt it was effective in reducing the symptoms of muscle damage and inflammation (e.g., muscle soreness) is therefore another limitation in the current study. Additionally, capturing dietary data would have strengthened our analysis and allowed us to highlight individuals with dietary deficiencies. Future studies with larger samples, and multiple curcumin dosages are warranted to investigate if different curcumin regimens can lead to statistically different CRP and HPX levels in the elite soccer player.

5. Conclusion

To our knowledge, this is the first study to investigate the efficacy of a nutritional intervention aimed at reducing biomarkers of inflammation and pro-oxidant status in professional soccer players competing in the EPL. Our data demonstrate that curcumin ingestion at the dose and protocol prescribed is not effective for attenuating biomarker responses in elite soccer players competing in the EPL. Future studies should look to

implement a more targeted approach to anti-oxidant supplementation in elite sport, involving the individualized examination of redox and inflammation status in athletes to allow for the identification of responsive phenotypes and the detection of meaningful physiological changes in individual data. This may also help progress away from a 'one-size fits all' approach to the use of anti-oxidant/anti-inflammatory supplementation, which is often adopted in elite sport, by identifying periods where an individual may require (or not require) intervention, resulting in the administration of anti-inflammatory interventions at the appropriate time.

Highlights

- The present investigation questions the efficacy of curcumin ingestion, using the dose and protocol prescribed (total dose of 1000 mg of curcumin, as recommended by the manufacturer, the morning of game day -2 (GD-2), game day -1 (GD-1) and immediately post-game during each supplementation period) for the purpose of reducing inflammation and pro-oxidant status in elite soccer players when following their habitual diets.
- Future studies should look to implement a more targeted approach to anti-oxidant supplementation in elite sport, involving the individualized examination of redox and inflammation status in athletes to allow for the identification of responsive phenotypes and the detection of meaningful physiological changes in individual biomarker data.

Conflict of Interest

The authors declare the following conflicts of interest relevant to the content of this study. Diarmuid Daniels, Nathan A. Lewis, Georgie Bruinvels, Andrew Barr and Charles R. Pedlar are employees or consultants with Orreco Ltd. John Newell is the Principal Investigator of the Orreco Ltd-funded research project in the Insight Centre for Data Analytics, University of Galway. Orreco Ltd provide blood biomarker services to elite athletes.

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Perceptions of a 12-week mini-trampoline exercise intervention for postmenopausal women

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ABSTRACT

The aim of this study was to examine the views and attitudes of postmenopausal women who participated in a mini-trampoline exercise intervention to improve female specific health risk factors. Twenty-nine postmenopausal healthy women aged 59.34 ± 5.82 years completed an open-ended and anonymous questionnaire consisting of 13 questions about their current activity levels, their perceptions of the mini-trampoline exercise intervention, and their future exercise plans. Principles of thematic analysis were utilized to analyse survey responses whereby each response was coded and categorized into a higher order theme. Adherence to the mini-trampoline exercise intervention was high (89.3%) and general attitudes were positive. Most responses (89%) suggested it was easy to participate. The most salient barriers to participation included work (24%) and personal commitments (20%). Women's responses (43%) suggested they would participate in a similar exercise intervention if it were offered at a gym. The highest-responding frequency and duration of the programme was reported to be 3 times per week (59%) and 40 minutes per session (31%). Local gyms could consider implementing a flexible scheduled, group-based mini-trampoline exercise programme that occurs at least three times per week for 40 minutes as these programme characteristics appear to be key for increased adherence to exercise in postmenopausal women.

1. Introduction

Older women are more likely than older men to develop conditions such as osteoporosis and urinary incontinence, which can decrease overall activities of daily living (MacLean et al., 2008; McGarry & Kiel, 2000). Regular exercise has long been recommended to reduce postmenopausal symptoms and increase physical functioning as well as quality of life (Shangold, Sherman, & DiNubile, 1998; Tolar, Teitelbaum, & Orchard, 2004). Yet older women have lower physical activity levels than men; just 27% of women over the age of 65 years meet daily recommended activity goals (Findorff, Wyman, & Gross, 2009). Older women and men alike have difficulties adhering to exercise programmes (Moore et al., 2020; Tak, van Uffelen, Paw, van Mechelen, & Hopman-Rock, 2012) such that 10 – 15% of older adults who start a structured exercise programme are known to drop out during the first six months (Tak, van Hespen, van Dommelen, & Hopman-Rock, 2012). Future exercise programmes that target older women should focus on known facilitators (e.g., enjoyment, duration, setting, level of self-efficacy, programme tailoring) (White, Randsdell, Vener, & Flohr, 2005) and strategies that allow women to overcome barriers (e.g., lack of time, money, social support, transportation, exercise experience) and increase their adherence to exercise (Forkan et al., 2006; Moore et al., 2020; Tak, van Uffelen, et al., 2012).

Mini-trampolines solve many of the challenges that prevent women from exercising. They are relatively inexpensive, small, portable, and offer all the benefits of a low impact exercise, while being performed in small, confined spaces, including at home

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(Weston, 2001). The level of effort exerted by an individual on a mini-trampoline exercises is easily self-adjustable, thus allowing for an effective workout for different women with different fitness levels (Aragão et al., 2011). Mini trampoline exercise programmes can improve physical fitness and also female-specific health risk factors, such as osteoporosis (Aragão et al., 2011; Bunyaratavej et al., 2015; Cunha et al., 2016). However, most research-based exercise interventions measure success solely on improved physical outcomes; no published research has examined the views and attitudes of women who participated in a mini-trampoline exercise intervention. Yet, it is important to consider participant perceptions of an exercise programme to examine its acceptability and sustainability as well as its effectiveness, particularly in older women who have specific motivators and barriers to exercise. Therefore, the purpose of this study was to examine the current views and attitudes of the programme from participants who completed a mini-trampoline exercise intervention study.

2. Methods

Participants were involved in a larger mini-trampoline exercise intervention (Fricke et al., 2021) to improve functional fitness and female-specific health risk factors in older women. The 12-week exercise intervention comprised of three 40-minute sessions held each week for 12 weeks, with pre- and post-tests as well as a 3-month follow-up. The research gained ethical approval from the Massey University Ethics Committee (Southern A 18/52). All women who participated in the intervention group of the exercise intervention study were contacted via email after completing the intervention and follow-up assessment. Each e-mail included a link to an online, anonymous questionnaire developed by two authors (AF, SS) within Google Forms. Survey questions asked participants to discuss their current physical activity levels, their perceptions of various components of the mini-trampoline, exercise intervention, and their future physical activity plans. All 13 questions were open-ended, and participants were able to provide more than one answer for each question. One hundred percent of participants (n = 29) who completed the intervention also completed the questionnaire.

Participants' open-ended responses were managed in Excel (Microsoft, Version 2002) and analysed using principles of thematic analysis (Green & Thorogood, 2005). Answers for each question were independently coded by the first author and a second researcher (ER) into higher order themes using a thematic framework. The two coders discussed the thematic coding for every individual response to each question until 100% agreement was achieved. Each question resulted in a varying number of themes. To determine the percentage in which a theme emerged, the following calculation was used:

$$\frac{N\text{theme}}{N\text{responses}} \times 100$$

where $N\text{theme}$ is the number of times a particular theme was mentioned and $N\text{responses}$ is the total number of responses for that question. $N\text{responses}$ varied between questions depending on the number of total responses provided.

3. Results

The completion rate for this intervention was 97% (n = 29; age = 59.34 ± 5.82 years; BMI = 27.62 ± 7.85 kg/m^2). The average attendance rate of women in this study was 89% (range: 80.5% – 100%). All (n = 29) participants who completed the exercise intervention completed the questionnaire; 97% (n = 28) reported to have participated in regular exercise prior to participating in the mini-trampoline intervention. Prior to this exercise intervention, 24% of total participants (n = 7) reported that nothing has ever stopped them from exercising. In contrast 28% (n = 8) reported that injury has previously stopped them from participating in exercise, 14% (n = 4) reported other health issues, another 14% (n = 4) mentioned a lack of motivation, while 10% (n = 3) reported pain or soreness throughout the body as a barrier to previously participating in exercise.

A detailed description of the five most salient higher order themes along with illustrative quotes for all survey questions can be found in the Supplementary material. Three questions focused on motivation to participate in a mini-trampoline exercise programme (Supplementary Table 1). Participants reported that social interaction was the most enjoyable programme characteristic and contribution to research was a primary motivator to participate. Similarly, three questions focused on barriers to participating in the programme. Participants (60%) found the exercises easy to complete and most commonly reported nothing unenjoyable about the programme. Work commitments were cited as being the primary barrier to participating in the programme.

Individual programme tailoring is a known facilitator for women's adherence to exercise (White et al., 2005). Participants provided feedback on optimal mini-trampoline exercise prescription (Figure 1). Most participants reported that no changes needed to be made to the format of the programme, and many agreed that the programme should include three 30-minute sessions per week.

4. Discussion

This study examined the current views and attitudes from older women who participated in a mini-trampoline exercise intervention to improve female specific health risk factors. The most enjoyable characteristics of this mini trampoline intervention were the social aspects of exercising in a group, the short duration bursts of exercise as well the instructor. Conversely, the most common barriers to participation included work, personal commitments, and transportation to sessions. Our mini-trampoline exercise programme aimed to address some of these barriers by providing the exercises for free, offering different locations and times and allowing women to participate in a different exercise session if they were unable to attend their usual session.

According to Pisters et al. (2010) an adherence level of at least 80% – 85% is recommended if the results of an intervention are to be satisfactory and if the intervention is to have therapeutic value. The higher adherence rate (89%) in this study is likely reflected in the overall positive views of participants about the mini-trampoline intervention. Research has shown that exercise interventions that involve socialization, support, and a sense of

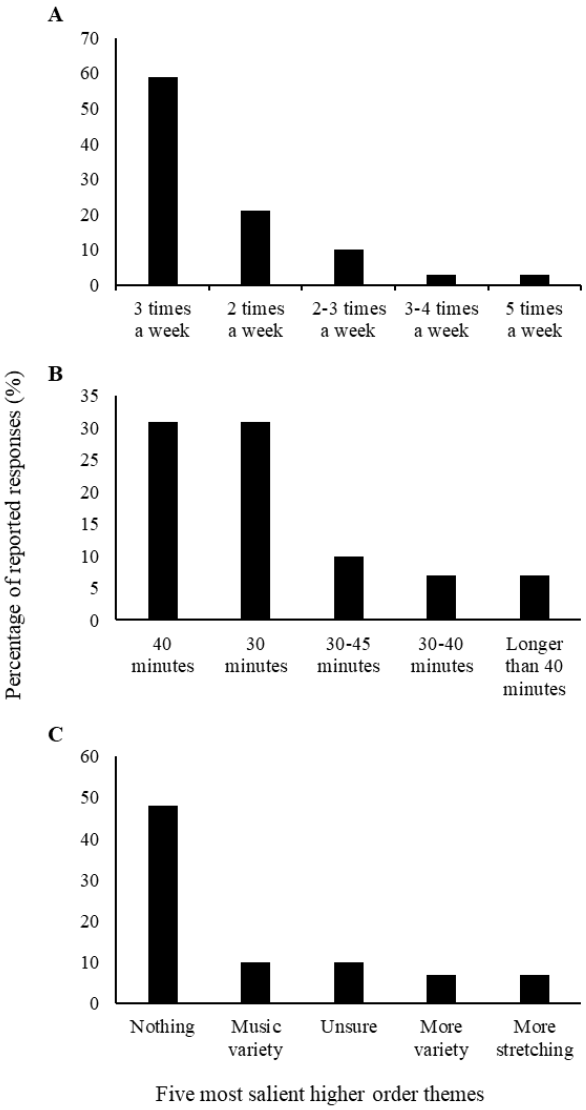

Figure 1: Salient higher order themes for preferred programme; (A) frequency, (B) duration, and (C) formatting.

group cohesion promote adherence to the programme (Caserta & Gillett, 1998). This mini-trampoline intervention only included women who were of similar age and postmenopausal. The similarities shared between participants potentially enhanced the opportunities for participants to bond and feel more confident about participating in the programme (White et al., 2005). Older women prefer to follow supervised exercise programmes (Jordan et al., 2010; Picorelli et al., 2014) and adherence to exercise programmes can be improved by having a knowledgeable instructor who can provide feedback and be seen as a peer (Caserta & Gillett, 1998). The preference for supervised exercise was supported by the current results, as participants mentioned the instructor as one of the most enjoyable characteristics in this intervention. Previous research has shown that women had higher adherence rates to exercise interventions that were scheduled, as is typical for supervised exercise sessions, and women might not make time for exercise unless they have a specific class to go to (Caserta & Gillett, 1998). The duration of exercise sessions in an exercise programme is also an important determinant for improving adherence (White et al., 2005). The short duration of each exercise session and the scheduled exercise times (with flexibility to shift times and days when needed) were important characteristics of this intervention's effectiveness.

The majority of women in our intervention (89%) said it was easy to participate; however, there were some barriers for participants to overcome. The most common barriers reported for participation included work, personal commitments, and transportation to sessions. Participants enjoyed being able to make up for missed sessions by joining one of the other classes that were offered. Thus, to increase adherence for an exercise programme tailored to older women, a mixture of supervised scheduled sessions and home-based sessions might be ideal, as it includes some structure but still offers flexibility by exercising at home anytime as well. Furthermore, offering a mixture of supervised scheduled sessions and home-based sessions would reduce barriers around transportation and other commitments since an at home workout can be completed at any time.

Responses regarding the difficulty of mini-trampoline exercises varied slightly, although most women considered the exercises to be easy and did not feel any fatigue. Evidence from other research suggests that adherence to an exercise programme is increased at lower perceived intensity levels (White et al., 2005). Exercise intensities that are perceived to be low may increase adherence as women will not sweat, have to change clothes, or anticipate soreness that comes with higher perceived intensities (White et al., 2005). Furthermore, studies have reported significantly higher injury and drop-out rates for higher intensity exercises compared to moderate or lower intensity exercises (Cox et al., 2003; Perri et al., 2002). Lower intensity exercises may also lead to greater adherence rates due to increased self-efficacy (Woodgate, Brawley, & Weston, 2005).

The majority of women reported interest in purchasing a mini-trampoline and/or would participate in a similar programme if offered at the gym, depending on the cost. Optimal exercise prescription included three 30-minute sessions per week with revised formatting that included a larger variety of music and exercises, as well as more stretching exercises at the end of a session. Although the exercise was well-received, the intervention was only three months long. Attendance rates of exercise programmes tend to be higher at the start of the programme, but can decrease quickly and significantly after six months (Caserta & Gillett, 1998; White et al., 2005) Further research is needed to determine if post-menopausal women can maintain adherence to a mini-trampoline exercise intervention after the 6-month threshold.

Conflict of Interest

The authors declare no conflict of interests.

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Supplementary material

Supplementary Table 1: Full description of top 5 salient themes for all survey questions.

Theme	Theme in response n (%)	Example quotation
Question 1: List three things you like about this programme.		
Social interaction	22 (24)	"Doing exercise with other likeminded and same age group. Doing exercise that was achievable in short burst. Doing exercise with women only."
Duration of session	9 (10)	"Music, socialisation, duration, intense but shortish"
Instructor	9 (10)	"Fabulous teacher, great social event, fitness level increased"
Music	6 (7)	"Music, social support, leadership"
Fun/enjoyment	6 (7)	"Trainer, I saw fast results, fun"
Question 2: List three things you didn't like about the programme.		
There was nothing that was unenjoyable	14 (41)	"None"
Travel to sessions	6 (18)	"Travel to and from class"
Missing sessions	2 (6)	"Having to miss sessions, jumping with the ball between your legs"
Specific movement of exercises	2 (6)	"Just that one exercise (2 kg weights while running and arms to front!)"
Music	2 (6)	"Distance travelled, some of the music"
Question 3: Why did you take part in this intervention?		
Contribute to research	12 (23)	"Thought it was a really interesting research programme"
Potential health benefits	11 (21)	"Good for me and needed improve health and fitness. Commitment to attend easier knowing it was helping research. Timing workable for me"
Novel exercise	5 (10)	"Its's a novel form of exercise"
Fun exercise	5 (10)	"Sounded like fun"
Free exercise	4 (8) [a]	"No cost to me. Regular, healthy exercise. To help out."
Question 4: What barriers did you need to overcome to participate in this exercise intervention?		
Work commitments	6 (24)	"It was a bit tricky balancing it with work"
Personal commitments	5 (20)	"It was easy except missing once for other commitments/appointments"
Transportation to sessions	4 (16)	"Just a long way to travel"
Poor weather	3 (12)	"Cold, rain, winter"
Organisation	2 (8)	"Organising my time to make it every week"
Question 5: How hard did you find the mini-trampoline sessions?		
Easy	9 (36)	"Not hard at all. I looked forward to each session"
Easier as programme progressed	6 (24)	"After a few weeks it was easy even though we 'knew' the sessions were increasingly more energetic and longer"
Required reasonable effort	5 (20)	"Had to push myself. I felt tired afterwards, especially for the first month"
Somewhat hard	1 (4)	"It was tiring but achievable"
Certain exercises were hard	1 (4) [b]	"The weights were the toughest – when we started using them a lot. My arms would ache for a few days"

Question 6: Were you fatigued for days after?		
No fatigue	9 (56)	"No issues with fatigue"
Fatigue that dissipated	2 (13)	"Didn't find them hard. Tried to keep up reasonable pace so good workout. First week or two tiring"
Experienced some soreness	1 (6)	"Not till the last couple of weeks, not so fatigued but very sore and stiff"
It was fatiguing	1 (6)	"It was exhausting and tiring but I knew it was good for me so I just did the best I could"
Experienced some fatigue	1 (6) [c]	"First session was really hard and I was sore afterwards but then got better. Exhausting and tiring but knew it was good"
Question 7: If the same programme was run at a gym/community centre, would you take part?		
Yes	13 (43)	"Yes, most definitely"
Yes, depending on affordability	5 (17)	"Yes, provided it was not too expensive"
Maybe	4 (13)	"Quite possibly"
No	3 (10)	"No"
Yes, depending on location	2 (7)	"Yes, I think so. Dependent on closeness of venue"
Question 8: How do you view sport and exercise now?		
No changes in attitude towards exercise	5 (16)	"No different than before as I already exercise regularly. I look forward to exercise"
Enjoys group exercise	4 (13)	"It is a chore mostly but it has made me think of the group class style being easier rather than individual."
Enjoys exercise	4 (13)	"I enjoy exercise, I'm going to find something else to fill the gap."
Enjoys exercise but lack of time to do it	2 (6)	"I have never minded exercise, but the time to do is not always available"
Motivation for exercise can be hard	2 (6)	"I never look forward to exercise but I know I have to do it so that I don't cease up later in life."
Question 9: What would you like to see added to this programme?		
Nothing	14 (48)	"Nothing"
More variety in music	3 (10)	"More variation in steps and music to maintain interest."
Don't know	3 (10)	"Don't know"
More variety	2 (7)	"Perhaps more variation but not sure what that would consist of"
More stretching	2 (7)	"More stretching afterwards"
Question 10: How many times a week do you think this programme should take place?		
3 times a week	17 (59)	"3 times a week was good. 12 times a month."
2 times a week	6 (21)	"Twice a week"
2-3 times a week	3 (10)	"2 – 3 times a week"
3-4 times a week	1 (3)	"3 – 4 times a week"
5 times a week	1 (3) [d]	"5 times a week"
Question 11: How long should each session last?		
40 minutes	9 (31)	"40 minutes was good for me."
30 minutes	9 (31)	"30 minutes is great"
30-45 minutes	3 (10)	"30-45 minutes"
30-40 minutes	2 (7)	"30-40 minutes is good"
Longer than 40 minutes	2 (7)	"I found the exercise sessions were a little short especially as I gained fitness and expertise"

Question 12: Do you have activity plans for the future?		
Back to original activities	10 (34)	"Back to yoga and beginning swimming"
Continue trampoline exercises at home	6 (21)	"I hope to keep jumping at home"
Yes	3 (10)	"Yes"
Back to original activities and looking for something new	2 (7)	"I will continue to walk, participate in zumba and stretch. I am looking at arthritis exercises for seniors."
Back to original activities and continue trampoline at home	2 (7) [e]	"I will continue with pilates, Mt Kaukau walks and commuter cycling and get back into my garden, but I also hope to continue using the mini tramp 3 times per week."
Question 13: Are you considering buying a mini-trampoline or have already bought one?		
Yes, considering buying one	10 (34)	"Yes, I am considering it"
Yes, already bought one	4 (14)	"I have bought one. I'm enjoying it."
Was given a trampoline from the intervention	3 (10)	"I was lucky enough to win one"
Had one prior the intervention	2 (7)	"Already had one which is also why I was keen to participate"
Yes, planning to buy one	2 (7)	"I was hoping to win one but I didn't! I now have it on a watchlist on trademe".

Note: [a] equal number of responses with "regular exercise"; [b] equal number of responses with "easy if sessions were not missed", "coordination was difficult but exercise easy", "difficulty level was progressive"; [c] equal number of responses with "experienced soreness towards end of the programme" and "experienced tired muscles but not fatigued"; [d] equal number of responses with "3 times a week with a weekend option"; [e] equal number of responses with "Nothing planned but need to make plans"

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Placebo doping in sport: Overview and ethical considerations

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ABSTRACT

Placebo effects in sports imply favorable performance outcomes generated by one's cognition. Placebo use is a form of non-detectible doping for placebo responders. They can be delivered openly or by deceiving the athlete. The current analytical review discusses placebo effects and looks at them in sports and exercise settings. It expands the critical messages of extant review papers with the analyses of two articles looking at athletes' and coaches' attitudes towards using placebo doping for enhancing performance in sports. The report highlights that the conclusions of literature reviews might be 'diluted' because their studies involve 'placebo responders' and 'non-responders.' Hence, some effects measured in responders are lower due to no effects in non-responders. Further, the report also stresses that the nocebo effects are more potent than placebo effects; therefore, coaches should be especially cautious about their words with their athletes. Last, the paper examines ethical issues and discusses how coaches may get a green light to use placebo doping to exploit their athletes' mental power.

1. Introduction

The placebo and nocebo effects mirror the human mind's power to influence a future outcome. Jean Baptist Girard claimed that "by words, we learn thoughts and by thoughts, we learn life" (Mart, 2010, pp. 152). Indeed, words are powerful and influence us consciously and subconsciously. Spoken or written words can please or hurt. They are a primary channel of thought manipulation. Then thoughts influence our feelings and actions, the whole human behavior. Indeed, Epictetus thought that things (themselves) do not affect us but rather do the mental ideas (thoughts) we create about things (Toulmin, 1979).

A decade ago, a German team published a review paper on the power of words used by doctors in communicating with their patients (Häuser et al., 2012). Based on their systematic analyses, researchers concluded that doctors should receive special education in communication to complement their medical training because their words substantially impact the prognosis of the illness. Simplifying the message of the paper: Words can heal or kill.

Most people are familiar with various pain and inflammation-reducing pills. Some may use it regularly. So do athletes for multiple ailments and even for ergogenic aid (Warner et al., 2002). Like every medication, these drugs also come with a patient information leaflet listing all known potential side effects. Generally, those who have previously used them do not bother reading the leaflet because they *know* that the specific medication yields the desired result.

This practice exemplifies conditioning occurring via mental cause-and-effect associations established through experience. On the other hand, those who read the information leaflet describing the side effects may decide not to use the medication. However, if they still use it, the chance of experiencing side effects increases (Colagiuri et al., 2012). Why? The answer relates to *expectancy effects* associated with the unknown (yet unexperienced) for which the individual has not developed a mental schema.

Indeed, Watson, the father of behaviorism (Watson & Kimble, 2017), who Pavlov greatly influenced, claimed that all behaviors result from conditioning and the influence of past experiences. As such, Watson seemed to ignore the subjective mental schema, which is the unique cognitive neural network of the individual. However, this connection is essential because a *specific* stimulus (like an orange) can produce different responses in different people.

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1.1. Objectives

This theoretical overview has three objectives. The first is a brief presentation of placebo and nocebo effects in general. The second objective discusses placebo and nocebo effects in sport and exercise, focusing on how research data might be "diluted" by opposing responses to placebo interventions. Finally, the third objective is the ethical consideration of using or not using placebo interventions in sports and exercise settings.

2. First objective: The placebo and nocebo effect

A placebo is an inert pill that should not have any systemic effect, as described in medicine (Finniss et al., 2010). Instead, the results of placebo administration stem from individuals' experiences- and information-based thoughts (or mental schemas) determined by unique past life events and associated expectations. The term placebo comes from Latin, which translates as: 'I will please' or 'I shall please'; Nocebo is the opposite: 'I will harm,' or 'I shall harm' (Jilch et al., 2020).

A nocebo is an inactive substance/agent or ineffective intervention to induce negative expectations, such as giving a sham treatment and saying it will hurt (Häuser et al., 2012). The placebo and nocebo can be agents, events, or actions. The placebo effect surfaces in a pleasant outcome, while the nocebo effect yields a harmful result. In the medical dictionary, a placebo is defined as "an ineffective medicine but may help relieve a condition because the patient has faith in its powers" (Kellett, 2012, p. 46).

This definition is limited, but it contains two words that merit evaluation. These words "may help" and "faith." Faith reflects thought, belief, trust, or conviction. May help (in the context of faith) suggest that it is *conditional upon faith*. Very long ago, Hippocrates recognized that some patients got better because of their *faith* in their physician, even though their health condition was devastating (Potts, 2021). Some people may recall that once they felt unwell, they went to the doctor, and after a few minutes of consultation, they already felt better, relieved, and reassured. If so, the doctor probably used the right words to reduce the agony. People see their doctors because they *believe* that the doctor can help.

One's belief in the doctor's ability to help reflects a positive expectation. If the doctor helped successfully in the past, the cognitive association between seeking help and the resulting outcome generates a *conditioned* expectation. If a person holds a negative expectation about the doctor's ability to help her, that person won't bother to go back for another consultation. A bad experience with a particular doctor creates negative expectations and generates avoidance behavior; the person will likely seek the help of another doctor.

Expectations can be '*certain*' (equivalent to a conviction) or '*uncertain*' and range between these two ends of the spectrum. Ploghaus et al. (2003) produced robust neuroimaging evidence for *certain* expectations activating different areas in the brain in contrast to uncertain expectations. For a placebo effect to occur, one should hold certain expectations about the efficacy of the placebo agent. However, different expectations originate from a complex set of personal-situational interactions associated with the person's learning and experiences.

Figure 1 below illustrates how the placebo/nocebo effect surfaces in one's mind. The central point is the *situation* in the context of the placebo. The evaluation of the actual situation depends on the *unique* mental schemas of the individual. Hence, it is idiosyncratic. These schemas are conditioned – or created based on various information and related experiences – mental frameworks resulting from upbringing, formal and informal education, and vicarious and personal experiences. Nowadays, however, people's schema is primarily affected by the immediate social environment and media information, especially the internet. So, evaluating the efficacy of the potential placebo could yield high- or low-level certainty expectations. But high-level expectations can be positive or negative and thus produce placebo or nocebo effects. If this happens, the person is called a responder (Tetreault et al., 2016). Being a responder or non-responder is determined by genes, personality, and situational interactions. Thus, even predisposition does not make one a responder in all situations; however, like hypnotic susceptibility, some people are more predisposed to be placebo responders than others.

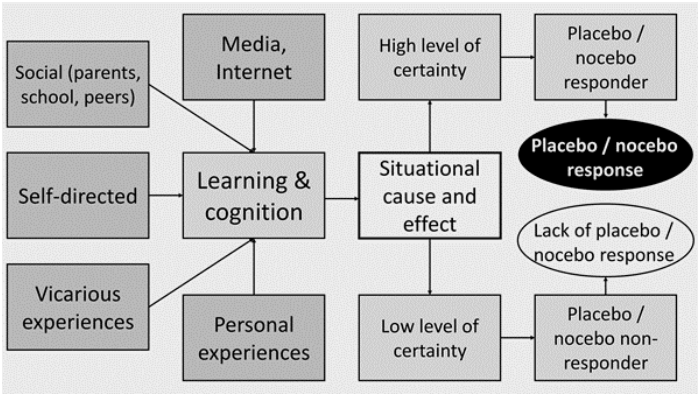

Figure 1: Diagrammatic illustration of the mechanism of placebo and nocebo effects.

A study used functional magnetic resonance imaging (fMRI) to detect the differences between placebo responders and non-responders to a placebo pain reliever. It showed a high level of brain activity in the mid-frontal gyrus in the placebo responders, absent in the non-responders (Tetreault et al., 2016). Therefore, there is robust neurophysiological evidence for the difference between placebo responders and non-responders.

Another study published earlier (Rief et al., 2011) induced thermal pain in healthy subjects, then provided them with a potent pain reliever under three conditions: 1) no expectation under a hidden treatment condition, 2) inducing positive expectation, and 3) inducing negative expectation. Subjects rated their level of pain on a zero to 100 rating scale. Hidden analgesia decreased the perceived pain compared to baseline. Analgesia associated with positive expectations doubled the effect of the analgesic. However, analgesia accompanied by negative expectations canceled out the impact of the analgesic agent. The authors also demonstrated that positive and negative expectations activated different areas in the brain. Earlier work suggests that expectations raise brain glucose metabolism by up to 50%, especially in the thalamus region associated with reward and conditioning (Volkow et al., 2003).

3. Second objective: Placebo and nocebo in sport

In sports science, scholars often use randomized control trials (RCT) in which participants are allocated to active treatment and placebo and, preferably, a no-treatment control group. This intervention can be combined with a double-blind design in which neither the experimenter nor the subject is aware of group allocation. Alternatively, a deceptive strategy can be used in which the participants think they receive an active treatment but receive a placebo.

Although argued for inclusion (Kayser, 2020), placebos are not on World Anti-Doping Association (WADA) prohibited list. The reason is simple: they cannot be detected. Therefore, a coach can almost freely use a concealed placebo administration in applied sports settings, which could be considered unethical (Beedie & Foad, 2008). Since placebo administration is a form of doping that is undetectable, many coaches still use it (Szabo & Müller, 2016). However, an open, active treatment is also possible. In this case, the coach offers legal ergogenic aids to the athletes, who know they are receiving it. Beedie and Foad (2009) wrote the first narrative review in the area based on 12 intervention studies, 11 of which surfaced after 2000. Accordingly, this research area in sports sciences is relatively young. After reviewing the 12 studies, the authors concluded that the placebo effect is present in sports. Bérdi et al. (2011) conducted a meta-analysis to examine the *magnitude* of the placebo effects disclosed by Beedie and Foad (2009). This first meta-analysis in the area included 14 studies encompassing 196 participants. The placebos were caffeine, oxygenated water, carbohydrates, and amino acids. The measures were physiological- or performance-related (e.g., muscle power, heart rate, running speed) and psychological attributes (perceived exertion, post-experiment self-evaluation of performance). The effect sizes varied from very low to very high, with an unweighted mean effect size of 0.40 and a variance-weighted effect size of 0.31, according to Cohen (1988), reflecting a low to medium effect. So, our meta-analysis confirmed Beedie and Foad (2009) conclusions and showed placebo *interventions* produce a small to medium effect on physiological, performance, and psychological measures.

Here comes an important point. The reviewed studies in Bérdi et al. (2011) paper included responders and non-responders. Indeed, none of the studies distinguished between placebo responders and non-responders. Thus, what is the logical conclusion? The 'possible' presence of non-responders dampens the results. Hence, we can safely posit that the effect sizes would be more significant in placebo responders (i.e. when controlling for non-responders).

These results prompted Szabo (2013) to think about the psychological effects of a single bout of exercise, which are almost exclusively positive. Many models exist for immediate positive psychological changes after a single training episode (Szabo & Demetrovics, 2022). They can be physiological, such as the thermogenic hypothesis (Koltyn, 1997), the sympathetic arousal hypothesis (Thompson & Blanton, 1987), the beta-endorphin hypothesis (Grossman, 1984), etc. Alternately there are psychological models such as the distraction hypothesis (Morgan, 1985) or cognitive appraisal hypothesis (Szabo, 1995). Still, none of these can fully explain the acute psychological effects of exercise (Szabo & Demetrovics, 2022). Therefore, Szabo (2013) proposed that the placebo effect could also be present in the immediate feeling states generally reported after an exercise workout.

There are several logical arguments for this hypothesis. First, physiological effects during exercise (i.e., increased sympathetic arousal and circulating β-endorphins; Szabo & Demetrovics, 2022) produce a pleasant feeling. Second, regular exercisers could get hooked on feelings, such as stress relief, that they experience after exercise (Chen, 2016). Consequently, they anticipate these feelings in response to their exercise training over time (Szabo, 2013). Finally, this expectancy may be *certain* (granted) due to prior conditioning. Therefore, a placebo (or at least a partial placebo) effect will likely occur. Substantiating this conjecture, Lindheimer et al. (2015) performed a meta-analysis on nine studies that used a randomized training protocol. Their results indicated that the mean placebo effect size was 0.20, and the observed effect of exercise training was 0.37. Consequently, they concluded that the *placebo effect accounts for approximately half of the psychological benefits of exercise* training.

Studies of ultra-short duration and low exercise intensity also corroborate the possible role of placebo effects in feeling states after an acute exercise session. For example, Szabo et al. (2013) conducted two studies. The first within-participants study examined young participants performing light, warm-up type exercises (consisting of arm, neck, and shoulder rotation and stretching) for three minutes. The second study replicated the first but also included a control group. In both studies, the short and light workouts triggered a statistically significant improvement in the perceived well-being of the exercise groups. Furthermore, the effect sizes were between moderate to large.

Another recent study (Ábel et al., 2022) showed that even after 50 m swimming lasting *less than one minute*, in either breaststroke or freestyle, the adult participants' feeling states, arousal, and positive affect increased statistically significantly, and the effect sizes were large. Unfortunately, this study did not gauge expectancy effects. Nevertheless, the fast-occurring significant psychological changes after less than one minute of swimming could be partially related to expectancy and placebo effects.

Bérdi et al. (2011) meta-analyses included less than 200 participants in 14 studies. Hurst et al. (2020) located 31 studies with over 1500 participants in a more recent meta-analytic review. These authors classified ergogenic aids into: 1) nutritional and pharmacological, 2) mechanical, and 3) psychological categories. Their results revealed that the effect size for nutritional and pharmacological placebos was 0.32; for mechanical placebos, it was 0.37; and for psychological placebos, it was 0.87. The pooled effect size revealed a small to moderate effect size of 0.35 across all studies, comparable to the effect size reported in the earlier meta-analysis by Bérdi et al. (2011). Again, these studies included both *placebo responders* and *non-responders*. Because the latter group could have diluted the effect sizes, the actual effects within the placebo responders might be more significant.

3.1. The power of words

Although based on only one work, Hurst et al. (2020) showed that the most significant effect occurred for psychological placebo. Indeed, psychological placebos, such as information priming, may be effective. For example, in a thought-manipulation study

(Szabo & Kocsis, 2017), researchers examined the effects of expectancy priming on the psychological effects of deep breathing lasting for only 3 minutes. Sport Science students were randomized into three groups. Two groups performed 3 minutes of deep breathing before their regular lecture. Deep breathing consisted of inhaling slowly over 6 seconds, holding their breath for 6 seconds, and exhaling slowly over 6 seconds. The difference between the two groups was that one received *misleading information* that 3-minutes of these practices could trigger similar mental results to a 30-minute intensive aerobic exercise. The other group performed the activity as a warm-up for the class but received no information. Finally, a control group sat quietly for 3 minutes. All three groups completed the positive affect negative affect schedule (PANAS) and a single-item momentary well-being feeling scale before and after the 3 minutes of deep breathing and the control condition. The results revealed that the expectancy-primed group increased statistically significantly in all measurements compared to the control group. Their scores differed from the non-primed group in positive affect and feeling states but not negative affect, which decreased by about 20% in both breathing groups. The non-primed group only differed from the control group in negative affect; even though they showed an overall 15% increase in well-being, this rise was statistically not different from the control group (Figure 2). Still, it was statistically significant from the baseline. Therefore, the authors concluded that information priming significantly augmented the effect of deep breathing by eliciting a placebo effect.

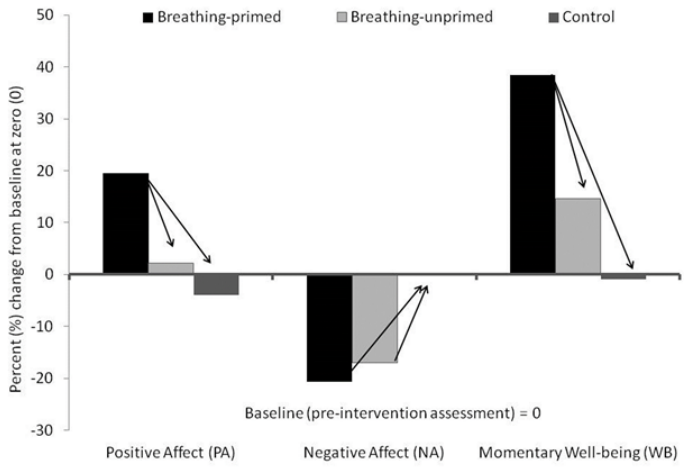

Figure 2: Differences between groups in three measures (Szabo & Kocsis, 2017).

In another study (de la Vega et al., 2017), researchers used a psychological placebo associated with a fictive green energy drink and tested its effects on 200 m running sprint performance. Initially, 60 long-distance runners were timed for their best run on a 200 m sprint. One week later, they were randomly assigned to three groups. The first group received *no specific instruction* and was told that the energy drink may or may not increase performance. The second group was told that the energy drink was laboratory tested to *increase performance*. Finally, the third group was told that the energy drink *had no effect on performance*, but its taste was good. After drinking the fictive energy drink that was only green-colored water, participants performed a gentle warm-up and reran a 200 m sprint. The experimenter who timed the sprint time was blind to the condition to which a given participant was assigned. The result replicated those obtained by Szabo and Kocsis (2017). A group-by-time interaction revealed that the positive instruction group showed the largest improvement in the 200 m sprint time. The 2.4 seconds average decrease (Figure 3) compared to the baseline was statistically significant. The slightly faster times in the neutral and negative instruction groups could reflect a habituation or practice effect; however, the *additional decrease* (change in these groups – change in the intervention group) in the positively primed group could show the effect magnitude of the positive information provided to the runners. These studies show how words affect human feelings and exercise performance.

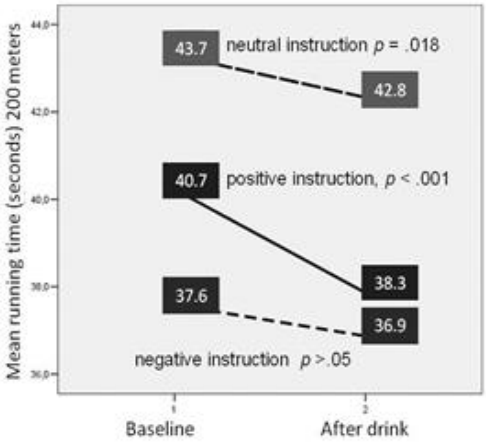

Figure 3: Decreases in seconds (s) in 200 m sprint time in three groups receiving different information associated with a fictive energy drink (de la Vega et al., 2017).

One may ask me why de la Vega et al. (2017) chose a green drink in the above study, not a red liquid or a white or red tablet. The answer might be connected to earlier work that found that green drinks were rated as the most efficient (placebo) for strength, endurance, and concentration (Szabo et al., 2013). This study presented nearly 300 undergraduates with *unlabelled* images of nine fictive ergogenic aids: green drink, green gel, red drink, white powder, white lotion, energy bar, red pill, white pill, and white capsule. Their task was to rank them separately (three times) in order of expected efficacy for sports *endurance, strength, and concentration* while simply thinking about the *perceptual characteristics* of the presented agents and not trying to associate them with any commercially available products. Results revealed that the green drink was perceived as the most influential on all three performance indices. This finding may not only justify the choice for the placebo in the 200 m sprint study but also shows that people's expectancy varies with the potential placebo agent's form, shape, and color. This finding has implications for the placebo agent's physical appearance and efficacy. For example,

two identical experiments could yield different results if the placebo differs only in shape, size, or color. Further, scholastic evidence suggests that the more invasive a placebo intervention is, the greater its efficacy (Wartolowska et al., 2014).

However, the impact of nocebo effects on motor performance is *nearly double that of the placebo effects*. For example, Horváth et al. (2021) showed that ten out of 12 studies using a between-participants research design in nocebo intervention research reported a nocebo effect. Furthermore, the mean effect size was medium to large (0.60), which is almost double that of placebo effects reported by Bérdi et al. (2011) and Hurst et al. (2019). The authors concluded that nocebo effects influence motor performance and can be evoked by negative words. This finding has substantial implications for coaching in that coaches should consciously choose their words in communicating with their athletes to avoid inducing a nocebo effect. In line with Häuser et al. (2012), like doctors, coaches should also receive education in communication.

3.2. Athletes and coaches

Knowing from the literature and our earlier studies that a placebo could influence athletic performance, Bérdi et al. (2015) studied 79 *elite* athletes' attitudes toward placebo use in sports. The first question asked participants if they had experienced a placebo effect in the past (placebo was defined for uniform interpretation before delivering the survey). Nearly half (i.e., 47%) of the respondents answered 'yes.' The second question was whether placebos could affect their performance, and 82% answered 'yes.' Then, they indicated the extent to which they believed placebos could be used in sports. Again, the answers to this question were related to previous experiences. Those who had already experienced placebo effects on their performance scored statistically significantly higher than those who did not have such experience. This tendency in the answers mirrors the effects of conditioning. The results also revealed that most athletes would accept a performance enhancer from their coach conditionally upon legality and absence of health hazards (and about 10% unconditionally). Less than 10% of the elite athletes indicate that they would feel unhappy about the deception. Finally, about two-thirds of the athletes indicated that they did not mind being deceived as long as the placebo intervention served their objectives.

Consequently, the authors concluded that there appears to be a green light for 'green drinks' in elite sports. This conclusion is based on the results that around 90% of the examined athletes conditionally or unconditionally would accept a placebo deception as long as it serves their performance. The implication is that placebo doping seems to be endorsed by elite athletes.

A later study (Szabo & Müller, 2016) replicated Bérdi et al. (2015) survey with 93 coaches working at regional, national, and international levels. Again, the first question was whether they experienced a false expectation or belief influencing an athlete's performance. Over 90% of the coaches responded yes. The second question asked whether they have provided a placebo to their athletes with the message that it would enhance performance. Again, about 44% of the coaches answered yes to this question. Among those who responded yes, 93% said that their action improved the athlete's performance, and only 7% observed no change, but *none reported worsened performance*.

Similar to athletes, coaches who experienced positive results with placebo administrations scored higher on the question about the broader use of placebos in sports than coaches who did not use a placebo in the past. Next, when asked what they think about the athletes' reaction if they would offer them a new performance-enhancing agent or intervention, their responses almost mirrored those of athletes. For example, 12.5% believed that athletes would accept the agent unconditionally, over 75% conditionally, and only about 10% would not accept it under any condition. It appears that coaches are not only aware of the benefits of placebo interventions and the openness of their athletes towards receiving such an intervention, but a significant proportion of them, especially those working at a higher level of competition, use placebo treatments in their coaching practice.

3.3. Superstition

Placebo effects also drive superstition in sports (Dömötör et al., 2016). A superstition is a form of self-administered placebo. A literature review reveals that elite athletes are the most superstitious (Dömötör et al., 2016). The superstitious ritual helps an athlete's confidence and guards against potential negative thoughts associated with not performing the superstitious routine and its consequences. It often sets the stage by helping the athlete feel relaxed, confident, and focused on the upcoming performance. Dömötör et al. (2016) concluded that the mental benefits of superstitious behavior in sports surface from the placebo effects. Conversely, not performing a mentally conditioned ritual could make the athlete feel uneasy and anxious and thus evoke a nocebo effect on performance. Therefore, superstition could be comprehended as a form of self-administered placebo in athletes.

4. Third objective: Ethical consideration

In their first review, Beedie and Foad (2009, pp. 325) posed a valid question: "Could the placebo response be used to enhance performance in competition, and if so, would it be ethically acceptable to do so?" Of course, there is no problem if the placebo is self-administered like a superstitious ritual or presented openly to the athlete as a placebo (Colloca, 2015; Dömötör et al., 2016). For example, 'Take this sugar pill and think it gives you wings.' Open placebos work. For instance, Szabo et al. (2018) showed that an ordinary tic-tac (a mint) had a more significant positive psychological effect than a placebo pill delivered as a super mood-enhancer. There are no ethical issues when a preferred outcome occurs through an agent that is harmless and honestly (openly) presented to the target person (Colloca, 1995).

However, based on current international ethical standards and regulations, there is a problem when another misleads a person. But is deception always harmful? Let's illustrate the point with two fictive examples. In the first example, a doctor shares terrible news with a patient concerning her health. The doctor tells her the pathology test results; she has cancer. The patient's mental framework, or schema network, is running the cognitive program, concluding that she will die since her cancer is deadly. The mind's conclusion is a horrible subjective verdict that influences the neuropsychoimmunological system via a negative schema. Indeed,

research shows that negative thoughts may further damage one's already fragile health (Thomsen et al., 2004). And who knows what the consequences of the self-fulfilling prophecy will be?

In the second example, a coach gives a super placebo pill to an athlete suffering from knee pain during a crucial game with the message that it will help relieve the pain. The athlete is deceived, but the placebo works, and the athlete can finish the game. The mental response to swallowing the pill is the *activation of pain regulatory pathways*, as shown earlier by Rief et al. (2011), which then alleviates discomfort and permits the continuation of the play. Knee pain has also been resolved through sham surgery (Sihvonen et al., 2013); therefore, placebo effects in knee pain regulation are not hypothetical but appear empirically supported.

In the first scenario, the truth can harm, which may induce further damage. In the second scenario, deception may heal or inspire. So, one should think for a moment and examine the personal attitudes concerning *goal- or desired outcome*-serving deception and harmful or *debilitative truth*. In doing so, one may ask why a child is receiving a vaccine comforted with deceptive words like 'it won't hurt' or 'you will feel a small peck only' for a moment. Can deception provide comfort and reassurance or avoid emotional harm in some situations?

Should ethical views, rules, or regulations that have the potential to harm be challenged? In addition to the philosophical principle '*first do not harm*,' perhaps ethical practices should consider the individual's will, well-being, and experience(s). Nations that have legalized euthanasia have considered these issues. In sports and exercise, the same factors are not a life and death matter but could account for determinants of success like time in which even a slight improvement can differentiate the gold from the silver medalist.

We know that coaches often use placebos in sports (Szabo & Müller, 2016), including deception. But apparently, most athletes *do not mind being deceived* as long as it helps them achieve their goals (Bérdi et al., 2015). However, does the coach indeed manifest a 'good' intention in supporting the athlete through this act? The success of the athlete is also the success of the coach. Therefore, some 'selfish' incentives may also be behind the seemingly supportive action. Some athletes may lose confidence in their coach if the act surfaces. Others may feel like victims of manipulation. Finally, one's athletic career may suffer due to the coach's actions.

Thus, when and how is it appropriate to employ a *hidden* placebo in sports and exercise settings? First, athletes' attitudes should be known in advance. They, like medical patients, should be informed that they will receive a placebo but may not necessarily be informed about the form and administration time (Colloca, 2015). Second, there must be a means to assess the possible change in attitude over time. Athletes who clearly and confidently affirm that they agree to be deceived as long as the deception serves their goal/performance and also consent to exposure to hidden placebo interventions may benefit from such actions.

Placebo doping, whether internal or external, concealed or open, resorts to the *power of the mind* to modify one's thoughts which could favorably influence performance (Szabo, 2013). In this sense, a placebo is a form of mental doping available to all and not detectable by doping tests. Hidden placebos should only be used after obtaining consent from the athlete, while open placebos can be used at any time but still only with the athlete's permission (Colloca, 2015). Coaches should never induce a nocebo effect and, like doctors, must be careful with their words when communicating with their athletes to avoid causing an unwanted nocebo effect.

5. Take-home message and research questions

5.1. What we know:

1. Sports coaches extensively use placebos with their athletes.
2. Most athletes have a positive attitude towards placebo use by coaches as long as that helps their athletic performance.
3. Placebo interventions are objectively undetectable.
4. Placebo interventions could help in sports/exercise performance.
5. A positive placebo experience reinforces approving attitudes toward placebo doping.

5.2. What we do not know:

1. What is the effect of open-label placebos on sports/exercise performance?
2. Does being a placebo-responder provide an unfair advantage to athletes exposed to placebo?
3. How resistant are placebo interventions to extension (i.e., weaken over time)?
4. Which forms of placebos are the most efficient in a typical sport/exercise?
5. Can a placebo be self-administered, and if yes, is it still a placebo (open-label placebo)?

Conflict of Interest

The author declares no conflict of interest.

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