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The effects of Netball specific preseason program on adolescent athletic performance and injury reduction: A pilot study

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ABSTRACT

Netball is a dynamic sport characterised by jumping and agility-based movements. The majority of New Zealand netball players are female, and many play from adolescence and make a lifelong commitment to the sport. Adolescent female players are more susceptible to lower limb injuries, in particular ankle sprains and anterior cruciate ligament (ACL) rupture. The increasing rates and impact of netball injuries may affect participation rates in the future. Injury prevention strategies are therefore a priority. In this study, a six-week netball preseason conditioning program was trialled to investigate the effects on athletic performance and injury prevention in adolescent athletes. A total of 112 participants were recruited from schools and netball centres from the Central Netball Zone of New Zealand and allocated to either a control (n = 30) or intervention (n = 82) group. Press-ups, prone and side holds, jumping performance and agility measurements were conducted at baseline and after the preseason conditioning program. Follow-up surveys were conducted to record the incidence of injuries during the season. At baseline, all performance measures were below the standards set by Netball New Zealand. Following the six-week preseason conditioning program, the intervention group recorded significant improvements in prone holds ($p < 0.05$) and agility ($p < 0.001$) compared to a control group. No change in jump performance measures were observed suggesting an intervention of greater than six weeks may be required to improve dynamic performance in this cohort of athletes. Injury incidence for the cohort was 13% over the season with less than 2% requiring surgery. This may suggest that in addition to any conditioning gains, there is value in the education associated with a preseason injury prevention program. This study advocates that a six-week netball-specific preseason conditioning program can improve some measures of athletic performance; however, further investigation is required to inform training practices in order to reduce injury incidence in adolescent female netballers.

1. Introduction

Netball is a dynamic sport involving acute changes of direction, balance, speed, and power movements (Reid, Vanweerd, Larmer, & Kingstone, 2015) which are associated with a high prevalence of lower limb injuries (Simpson, Reid, Ellis, & White, 2015). The most frequent injuries in netball involve the ankle and knee, representing approximately 19-22% and 37-58% respectively, of all netball injuries (Flood & Harrison, 2006; Hopper, Bryant, & Elliott, 1994). Ankle injuries have a higher incidence in females, almost double compared with males with indoor/court sports having the highest prevalence; 13.6 injuries per 1000 exposure hours (Doherty et al., 2013). The single most common netball knee injury is a ruptured anterior cruciate ligament (ACL), which generally requires surgical intervention and six to nine months of rehabilitation (Davis, Ireland, & Hanaki, 2006).

Netball is the most participated sport by females in New Zealand (Sport New Zealand, 2015). Of those participants in the Sport New Zealand survey 2013-2014 who identified as playing netball; 15.9% were aged 16-24 years old, and participation rates

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were greater than 20% in the age groups 25-39, 40-54 and 55-69 years old (Sport New Zealand, 2015). From 2008/9 to 2012/13 there has been a 34% increase of surgically repaired ACL attributed to netball injuries in New Zealand (Simpson et al., 2015). The likelihood of returning to the same level of sport following an ACL injury is between 45-80%, with a 20% increase in the risk of re-injury (Lohmander, Ostenberg, Englund, & Roos, 2004; Myklebust, Holm, Maehlum, Engebretsen, & Bahr, 2003). Adolescent females are two to eight times more likely to rupture their ACL than male counterparts (Michaelidis & Koumantakis, 2014). Given injuries in adolescence impact on the return to sport and increase the likelihood of subsequent injuries, there is a need to provide preventative programs particularly in female-dominated sports such as netball.

Substantial evidence supports the use of preseason conditioning programs (Abernethy & Bleakley, 2007), balance training and multifaceted training programs (Hübscher et al., 2010; Schiftan, Ross, & Hahne, 2015) specific injury prevention training programs (Sadoghi, von Keudell, & Vavken, 2012) and neuromuscular warm-up protocols (Herman, Barton, Malliaras, & Morrissey, 2012) to reduce the rate of knee injuries and lower limb injury incidences in various sports. Programs of six weeks or more that include education, strength conditioning, jumping and landing, agility drills and sport-specific skills have been found to improve landing biomechanics, vertical jump height, agility and strength which translates into enhanced athletic performance (Myer, Ford, & Hewett, 2004; Noyes & Barber-Westin, 2015). These programs appear to be most effective if they commence preseason and are continued in some format throughout the playing season (Abernethy & Bleakley, 2007; Myer et al., 2004; Noyes & Barber-Westin, 2015).

While sports such as football, volleyball and basketball have found benefits from implemented athletic and injury prevention programs, there is limited evidence for netball, particularly for adolescents (Taylor & Lander, 2018). This study investigated the impact of a six-week preseason conditioning program on both athletic performance and incidence of injury throughout the season for adolescent female netball players in New Zealand.

2. Methods

2.1. Participants

Female netball players between the ages of 13 and 16 years were recruited from within 13 centres and secondary schools in the Netball Central Zone (located in the lower North Island of New Zealand). Participants were allocated to the intervention or control group based on an assignment of convenience. Of the recruits, two of the netball centres and one of the secondary school teams formed the intervention group and participated in the six-week intervention program; the remaining centre and two secondary school teams formed the control group. A total of 112 adolescent netball players participated in the testing which took place in February and April 2016. The intervention group (n = 82) undertook the six-week conditioning program in place of their usual preseason preparation. The control group (n = 30) were instructed to continue with their usual preseason lead up. Pre-testing occurred over two weeks in early February 2016. Once pre-testing was completed for each cohort, the six-week intervention program commenced. Post-testing was completed the week following the final session in early April 2016. Due to reasons of practicability testing of the intervention and control groups was separated by one week, irrespectively participants completed the pre and post-testing at the same time and weekday. Prior to data collection, inform consent was obtained from the participants and their guardians. This study was approved by the Research Ethics and Approvals Committee, Eastern Institute of Technology, New Zealand.

2.2. Data Collection

Participant data was collected from the control and intervention group prior to any testing. Data collected included date of birth, the number of netball teams played for, the average number of training sessions per week, and the average numbers of games per week. From this information the total number of netball hours per season was estimated for each participant. Details regarding current and previous knee and ankle injuries were also documented before commencing pre-testing.

The pre-and post-intervention testing incorporated fitness components commonly associated with netball using methods described elsewhere in the literature: press-ups (Baumgartner, Oh, Chung, & Hales, 2002), prone and side holds (Kilding, Tunstall & Kuzmic 2008), jump performance (horizontal and vertical) (Harman, Rosenstein, Frykman, Rosenstein, & Kraemer, 1991; Maulder & Cronin, 2005) and the Illinois agility test (Cureton, 1951). All testing was conducted by the same person using standardised instructions and protocols. Before each testing session participants performed a standardised 10-minute warm-up that replicated a generic netball warm-up. After the warm-up and testing instructions, all tests were performed sequentially with up to a three-minute rest interval between each. Performance standards were obtained from data provided by NNZ (Netball New Zealand, 2014).

2.3. The Intervention

The six-week conditioning program was delivered by an experienced netball coach with a background in strength and conditioning between February and April 2016. The program included education, neuromuscular warm-up, single-leg balance activities, strength elements, jumping & landing training, netball specific skills and warm down. The single-leg balance tasks included static single leg balance while completing a variety of netball passes, complexity progressed through the program to dynamic single-leg balance adding Y shaped movements with the lower limb and ball reaches in multiple planes of movement. The jumping and landing training was adapted from previous research found to decrease the risk of knee injury (Hewett, Lindenfeld, Riccobene, & Noyes, 1999). For players between 13 and 14 years of age (Under 15) the program described in Table 1 was delivered twice weekly, for players between 15 and 16 years (Under 17) the program described in Table 2 was delivered three times per week, these volumes were chosen in accordance with Netball New Zealand (NNZ) player development guidelines recommended hours of netball and support activities (Netball New Zealand, 2017). At each of the

Table 1: Overview U15 preseason netball program

Element	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Education	Warm up Cool down	Being fit for netball	Eating healthy and hydration	Treating injuries	Skill development	Components of a netball athlete
Single-leg balance	Static	Static	Static	Dynamic	Dynamic	Dynamic
Jump training Hewett et al., (1999)	Technique	Technique	Fundamentals	Fundamentals	Performance	Performance
Netball specific	Attacking movements	Attacking movements Passing variations	Attacking skills Contesting the ball	Defense phases	Defense phases Working together	Defense pressure
	Duration or Reps by week					
Plank	2 x 20 sec	2 x 25 sec	2 x 30 sec	2 x 35 sec	2 x 40 sec	2 x 45 sec
Side Plank	2 x 20 sec	2 x 25 sec	2 x 30 sec	2 x 35 sec	2 x 40 sec	2 x 45 sec
Squats	5	8	10	12	15	20
Lunges	5 each side	6 each side	7 each side	8 each side	9 each side	10 each side
Nordic hamstring	2	4	6	8	10	12
Single calf raises	6	8	10	12	14	16
Press ups	2	4	6	8	10	12

preseason conditioning sessions, participant activity completion and attendance were recorded. This was documented as compliance at the completion of the intervention (total number of conditioning program activities completed divided by the total number of activities, multiplied by 100).

2.4. Injury Incidence

Injury incidence was monitored during the intervention period, no injuries were recorded. All participants were contacted every four weeks, during the post-intervention period (32 weeks), and were required to complete an injury questionnaire to disclose if they had sustained an injury in the previous four weeks. Information collected included the date of injury, activity when injury occurred, mechanism of injury including contact or non-contact injury, place of injury (training or game venues), time of injury (during training or during game), health practitioner care and medical scans, injury diagnosis, estimated time to return to play and actual time to return to play and whether surgical intervention occurred.

2.5. Data Analysis

All data analyses were performed using IBM SPSS Statistics software (version 24). Descriptive statistics (means and frequencies) were used to describe the baseline data collected at the pre-intervention testing. Baseline differences between the intervention and control groups were determined with either a students *T*-test (for mean value) or *z*-Test (for frequency proportions). Pre- and post-intervention testing differences were analysed using paired T-tests (2 tailed) as equal variances were observed. The change between pre- and post- interventions measurements were calculated for each member in the intervention and control groups and differences in change between the groups were explored using a univariate general linear model (dependent variable = change, factor = group). This set of analyses was repeated as a general linear mixed-effects model with the inclusion of age as a covariate. Relationships between netball hours within a season and current injury status were also investigated using Pearson's correlation coefficient.

Injury incidence pre- and post-testing was calculated as a percentage of intervention (n = 82), control (n = 30) group or as a percentage of all participants (n = 112). All tests used $\alpha = 0.05$.

Table 2: Overview U17 preseason netball program

Element	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Education	Components of a netball athlete	Physical conditioning	Nutrition overview	Injuries and prevention	Mental skills introduction	Goal setting
Single-leg balance	Static	Static	Dynamic	Dynamic	Dynamic	Dynamic
Jump training Hewett et al., (1999)	Technique	Technique	Fundamentals	Fundamentals	Performance	Performance
Netball specific	Attacking movement Passing variations	Attacking movements Passing accuracy	Attacking movements Court vision and balance	Defense phases and positioning	Defense team work and pressure	Defense team work and creating turnovers
	Duration or Reps by week					
Plank	2 x 45 sec	2 x 50 sec	2 x 1min	2 x 1min 5sec	2 x 1 min 10sec	2 x 1min 15sec
Side Plank	2 x 45 sec	2 x 50 sec	2 x 1min	2 x 1min 5sec	2 x 1 min 10sec	2 x 1min 15sec
Squats	10	12	14	16	18	20
Lunges	7 each side	8 each side	9 each side	10 each side	11 each side	12 each side
Nordic hamstring	6	8	10	12	14	16
Single calf raises	10	12	14	16	18	20
Press ups	6	8	10	12	14	16

3. Results

Baseline data shows the mean number of netball hours per season was approximately 200 hours for both groups. However, a cohort of ten players within the intervention group indicated involvement in school, club and representative netball teams inclusively, completed between 400 and 600 hours per season of netball. Of the ten players that indicated over 400 playing hours a season, seven of the ten indicated previous knee and/or ankle injuries and four of the ten identified current ankle injuries at pre-intervention testing.

Table 3 provides an overview of the participants' pre-intervention data. The control group (n = 30) had a significantly higher age than the intervention group (n = 82). The control group also had a significantly longer mean prone hold, and left and right-side hold times along with a higher mean Illinois agility test score. In contrast, the control group had a lower mean vertical jump height. No difference in right or left jump distance or power were detected. Pre- and post-intervention testing comparisons both within and across both groups are shown in Table 4. The six-week conditioning program intervention group had improved performance in press-up number, prone hold time, left and right-side hold time, and the Illinois agility test score (Table 4). Significant decreases in jump performances were observed, however these were all of a magnitude of less than 1cm (Table 4). No significant changes were detected for the control group who had similar in pre and post-intervention testing results with the exception of the Illinois agility test in which participants improved by 9.2 ± 0.65 seconds in comparison to the improvement of the intervention group of 0.6 ± 0.07 seconds. Significance persisted when comparisons were assessed using age as a covariate.

Weak correlations for the intervention group participants were found between condition session compliance and observed change in right side hold ($r = 0.270$, $p = 0.014$); and the number of sessions per week and change in the number of press-ups ($r = 0.25$, $p = 0.022$). Follow-up injury incidence data presented in Table 5 indicates a total of 15 injuries occurred during the 32-week netball season following the intervention, 12 from the intervention group and three from the control; this represents an injury incidence of 13% for the total cohort. The most common injury was an ankle lateral ligament sprain, the majority occurring during contact. Three significant knee injuries were recorded all with non-contact mechanisms of injury, two ACL ruptures (confirmed by MRI) in the control group and one patella dislocation in the intervention group. Of the two ACL injuries both required surgery which represents a surgery incidence of less than 2% of the study participants. A comparison of pre and post-intervention injuries demonstrated a reduction in knee injury incidence in the intervention group, however these figures failed to achieve significance.

Table 3: Participant profiles and pre-intervention testing results

Characteristic	Intervention Group n=82	Control Group n=30	All n=112	NNZ standards (2014)
Mean (SD)				
Age (years) ***	**15.0 (1.21)**	**16.7 (0.87)**	15.4 (1.36)	
Netball hours/ season	203.4 (111.51)	186.1 (108.20)	198.8 (110.42)	
Previous surgery (%)				
Ankle	2.4	3.3	2.6	
Knee – ACL	4.9	0.0	3.6	
Shoulder	1.2	0.0	2.6	
Pre-intervention testing				
Press-up (number)	6.8 (5.91)	8.1 (5.13)	7.2 (5.72)	15
Prone hold (s)*	**41.7 (34.61)**	**59.1 (31.13)**	46.4 (34.45)	60
Left side hold (s)***	**21.9 (15.26)**	**44.0 (20.12)**	27.8 (19.30)	
Right side hold (s)***	**25.1 (17.80)**	**41.4 (20.28)**	29.5 (19.78)	
Right jump (cm)	29.0 (4.58)	27.3 (4.15)	28.6 (4.52)	30
Right jump power (Watts)	640.9 (256.49)	635.6 (241.65)	639.4 (251.44)	
Left jump (cm)	28.8 (4.24)	26.3 (4.18)	28.1 (4.34)	30
Left jump power (Watts)	635.0 (253.96)	614.3 (228.30)	629.3 (246.379)	
Horizontal jump (cm)**	**181.3 (19.23)**	**169.0 (17.23)**	178.0 (19.43)	190
Illinois agility (s)***	**18.5 (0.78)**	**19.4 (0.84)**	18.8 (0.88)	

NNZ: Netball New Zealand; SD: Standard Deviation

Control and intervention group means in bold are significantly different at the level indicated by the number of asterisks: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$ derived from a students *T*-test. Control and intervention group percentages in bold indicate that are significantly different at the 0.05 level as determined by a *z*-Test

Table 4: Group comparison of the pre- and post-intervention mean test differences (95% Confidence Interval) in athletic performance measures

Measure	Intervention group		Control group		Between group
	n	Mean difference (95% CI)	n	Mean difference (95% CI)	p-value[1]
Press-up (number)	82	**7.1 (5.76, 8.37)*** **	17	2.5 (0.00, 5.06)	**0.004**
Prone hold (s)	82	**31.1 (22.90, 39.29)** **	17	13.6 (-7.10, 34.28)	0.085
Left side hold (s)	82	**23.8 (18.90, 28.66)***	17	3.0 (-8.80, 14.69)	**0.001**
Right side hold (s)	82	**24.4 (19.07, 29.76)** **	17	0.8 (-13.60, 15.13)	**0.001**
Right jump (cm)	79	**-0.6 (-1.10, -0.03)*** **	17	1.2 (-0.20, 2.60)	**0.008**
Right jump power (Watts)	79	**-12.1 (-23.51, -0.77)*** **	17	25.5 (-4.04, 55.10)	0.111
Left jump (cm)	79	**-0.5 (-1.03, 0.07)*** **	17	0.6 (-0.96, 2.20)	**0.008**
Left jump power (Watts)	79	**-10.3 (-21.93, 1.30)*** **	17	13.0 (-20.35, 46.43)	0.111
Horizontal jump (cm)	80	**-0.4 (-4.01, 3.17)*** **	17	-2.8 (-6.43, 5.86)	0.974
Illinois agility (s)	79	**-0.6 (-0.72, -0.45)*** **	17	**-9.2 (-1.40, -0.43)** **	0.073

95% CI: 95% Confidence Interval

Mean differences in bold indicate a significant difference between the pre and post-intervention test results at the level indicated by the number of asterisks: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$ derived from paired t-tests between pre- and post-testing measures. [1]*p*-value derived from one-way ANOVA (dependent variable=difference [post-pre], independent variable=group)

Table 5: Post-intervention follow-up of netball injury incidence

Injury date	Group	Age Years	Netball activity	Limb dominance	Diagnosis	Contact	MRI/ Scan	Time absent from sport	Surgery	Program adherence	Netball hours per season
April	Intervention	15.8	No	Right	Ankle lateral ligament	Yes	No	4 weeks	No	77%	218
April	Intervention	15.3	Yes	Bilateral	Anterior shin pain	No	No	0 days	No	77%	180
April	Intervention	15.5	Yes	Right	Peroneal strain	Yes	No	3 weeks	No	61%	72
April	Intervention	15.9	Yes	Right	Ankle lateral ligament	Yes	No	4 weeks	No	44%	147
May	Control	16.9	Yes	Right	Anterior cruciate ligament	No	Yes	9 months	Yes	n/a	293
May	Intervention	17.3	Yes	Left	Ankle Lateral ligament	Yes	No	2 weeks	No	72%	630
May	Intervention	16.1	Yes	Right	Patella dislocation	No	Yes	6 months	No	66%	405
May	Intervention	16.7	Yes	Left	Gluteal muscle strain	No	No	2 weeks	No	72%	293
May	Intervention	14.5	No	Left	Ankle lateral ligament	Yes	No	3 weeks	No	58%	184
June	Intervention	14.7	No	Left	Ankle lateral ligament	No	No	1 week	No	91%	92
June	Intervention	14	Yes	Left	Peroneal strain	Yes	No	1 week	No	91%	405
June	Control	15.8	Yes	Left	Ankle lateral ligament	Yes	No	2 weeks	No	n/a	518
July	Control	16.2	Yes	Left	Anterior cruciate ligament	No	Yes	9 months	Yes	n/a	218
August	Intervention	15.1	No	Right	Hamstring strain	No	No	4 weeks	No	91%	92
August	Intervention	13.1	Yes	Left	Ankle lateral ligament	Yes	No	4 weeks	No	83%	72

4. Discussion

The aim of this study was to investigate the impact of a six-week preseason netball conditioning program on athletic performance and injury prevention in adolescent netball players. The key findings from this study justify the implementation of preseason conditioning programs for adolescent athletes and provide insight into how to improve the success of these interventions within a wider framework of player development. The six-week intervention length was chosen in conjunction with netball center guidance as to the most common timeframe for centers to be able to bring players together.

Following the six-week preseason program, athletic performance indicators for strength (press-up, prone hold, left and right side hold) improved significantly such that at the end of the program the intervention group met the associated NNZ standards (Netball New Zealand, 2014). Whilst prone hold scores were different between the intervention and control groups at baseline, possibly as a consequence of age-related strength differences (Tanner, 1981), this difference was negated by the six-week training program.

Studies show that observing changes in jump height over six weeks are possible when including three sessions a week (Myer, Ford, Palumbo, & Hewett, 2005), however, the season timing and contact hours associated with this intervention were such that gains in jump height were not specifically observed. The results of the jump measures of the six-week program in this study were less affirming. Vertical and horizontal jump reduced following the six-week program, however the practical relevance of mean changes of less than 0.6cm could be questioned. Furthermore, assessment of landing kinematics may provide improved analysis of the jump training program and neuromuscular adaptations in preference to jump height and distance measures. Irrespective of changes, players at baseline averaged approximately 28 cm (left and right) jump height and 181 cm and 169 cm (intervention and control respectively); well below the national standards of 40 cm and 190 cm set by NNZ (Netball New Zealand, 2014). The preseason intervention incorporated a plyometric training program previously found to increase jump height and decrease the risk of knee injury by reducing potentially dangerous landing forces and increasing hamstring muscle power (Hewett et al., 1999). However, when analyzing the effects of plyometric training there is conflicting evidence supporting both improvement and slight reductions in jump height (Markovic & Mikulic, 2010). Factors such as muscle damage and residual fatigue are thought to negatively affect vertical jump height (Markovic & Mikulic, 2010), therefore, as training progresses jump height decreases. It is possible that this might explain the reduction in jump height seen in this study.

Being able to change direction at speed is a key attacking netball skill as well as representing a marker for reduced injury. One unexpected finding from this study was that agility improved in both the intervention and control groups over the six-week pre-season period. Systematic reviews have suggested the benefits of improved agility in injury prevention (Brunner et al., 2019; Sugimoto, Myer, Foss, & Hewett, 2015). However, the interesting aspect of this study was that despite no access to the conditioning program the control group improved in agility over the six-week preseason period. Although unconventional, it is not unsurprising that the control group, many of whom were engaged in school and club netball trials would improve over a six-week preseason time period in a test which so fundamentally represents netball movement skills. Whilst this makes the effectiveness of the conditioning program used in this study less easy to explicate, it does serve as a reminder that interventions and control measures need to be carefully considered in the context of multi-team, multi-season participants.

Previous research indicates that multi-faceted programs improve athletic performance and reduce injury risk however the effect of each program component on performance and injury indicators is unclear (Hewett, Ford, & Myer, 2006; Hübscher et al., 2010; Lauersen, Bertelsen, & Andersen, 2015; Michaelidis & Koumantakis, 2014). A novel aspect of this study was the injury incidence follow-up. Whilst there is no data to compare this variable with, it is satisfying to note the low incidence of injuries recorded by participants when compared with national statistics.

Netball, due to the nature of the sport and landing requirements, affords high risk for non-contact knee and ankle injuries. To prevent serious knee injuries, other sports have determined that programs completing balance, conditioning and skills training reduce injury risk by producing physiological adaptations (Abernethy & Bleakley, 2007). Alongside this, plyometric and strengthening (Hopper et al., 2017; Michaelidis & Koumantakis, 2014; Yoo et al., 2010), proximal control and multi exercise genres (Sugimoto et al., 2015), and programs targeting jumping (Weber, Lam, & Valovich McLeod, 2016) have been proven to be beneficial in the reduction of ACL injuries in adolescent females.

Recommendations suggest that neuromuscular training programs to prevent non-contact ACL injuries should be performed for 10 to 20 minutes at least three days per week in the preseason period (Grindstaff, Hammill, Tuzson, & Hertel, 2006). Combining this recommendation with the player development recommendations of NNZ (Netball New Zealand, 2017) and the demands of school, club and representative netball teams make the combination of best practice in adolescent conditioning and injury prevention problematic to implement. The preseason netball intervention program used in this study contained education, strength, balance, plyometric jump training and netball specific skills and while improvements were seen in strength measures, agility, reductions in jumping performance were observed. The jumping and landing program used had previously determined an improvement in the biomechanics of jumping, with a reduction in serious knee injuries thought to be due to increased dynamic stability (Hewett et al., 1999). More recent research has shown the benefit of other jump training programs on injury reduction in adolescent netballers (Hopper, Haff, Joyce, Lloyd, & Haff, 2017). The competing interests of conditioning programs aiming to improve jump height and reduce the prevalence of landing injuries add the complexity of analyzing the findings from jump training programs, and supports the need for further research in this space.

As the number of training and playing netball hours increases, the likelihood of injury also will increase (Doherty et al., 2013). In this study, there was a greater prevalence of previous knee and/or ankle injury within the cohort of adolescent netball players who participated in higher total netball hours (>400) than the other groups. However, there was no relationship between the number of netball hours participated in and the injuries

participants who were followed-up suffered during the netball season.

Whilst the injury incidence in this cohort was much lower than national expectations there is strong support from other studies for some form of injury program to continue throughout the season to provide a preventative effect (Abernethy & Bleakley, 2007; Myer et al., 2004; Noyes & Barber-Westin, 2015). Ideally, injury prevention starts in a preseason window, however as the netball season demands of adolescent netball players vary due to school, club and representative requirements there is justification in extending programs beyond a preseason intervention. This is supported by studies which show that lack of compliance or poor uptake of any injury prevention program are known concerns (Emery, Roy, Whittaker, Nettel-Aguirre, & van Mechelen, 2015) and that compliance significantly affects outcomes (van Reijen, Vriend, van Mechelen, Finch, & Verhagen, 2016) but if these are only measured preseason rather than extending throughout the season an opportunity to change the message around injury prevention is being missed.

Serious knee injuries such as an ACL rupture are devastating to a young athlete and have substantial consequences on adulthood quality of life. One of the features of this study is the low rate of injury incidence in the season that followed, this can only be of benefit to the maintenance of participation statistics in Netball. Further investigation of injury prevention programs should use more kinematic factors to describe their effectiveness, and should also reflect the common expectation that adolescent players will bridge traditional seasonal windows when playing at a school, club and representative levels.

This pilot study aimed to investigate the effects of a six-week netball preseason conditioning program on athletic performance and injury prevention in adolescent netball players. There are limitations to the current study in the balance of intervention and control groups, length of the program due to the size of the preseason conditioning window, and the variance brought to the study from participants playing for school, club and representative netball teams. However, this is the nature of the game for many adolescents, as such this study has a level of ecological validity which such be considered in conjunction with any limitations. It possible that other jump training protocols such as those from Hopper et al., 2017 could be more appropriate for future studies, but those decisions should be based upon the primary aim of each conditioning intervention.

5. Conclusion

Netball is a dynamic sport with an increased incidence of knee and ankle injuries in adolescent females, therefore, preventative programs are essential to reduce the rate of injury. The findings from this study indicate benefits to strength and agility from a six-week preseason program, however, the direct link between this program and the injury incidence below national expectations is unclear. Further investigation is required to evaluate the effectiveness of injury prevention programs for adolescent netballers, particularly in conjunction with the overlapping demands of school, club, and representative netball.

6. Practical Implications

Preseason injury prevention programs over six weeks can help reduce injury incidence during the season to below national expectations.

Strength gains may be achieved over six weeks; however, longer windows may be required for changes to jump performance in adolescents.

Conflict of Interest

Each author should reveal any conflict of interest. If there are no conflict of interests please state, “The authors declare no conflict of interests”.

Author Contributions

LT devised the study. HY acquired data. RF contributed to the analysis of data. PL contributed to the interpretation of data. All authors contributed to drafting and revising the manuscript. All authors provided final approval for publication.

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