Sub-phase analysis of the modified 5-0-5 test for better change of direction diagnostics

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A B S T R A C T

The aim of this study was to determine whether the utilisation of three timing gates could reliably measure different sub-phases of the modified 5-0-5 COD test, and whether these sub-phases were inter-related. The modified 5-0-5 COD test was adapted, and additional timing gates were placed at 2 m and 4 m, enabling acceleration, deceleration, 180-degree turn and reacceleration 1 and 2 too be measured independently. Ten elite female netball athletes (age: 24.9 ± 5.0 yrs, height: 180.1 ± 6.5 cm, weight: 81.3 ± 15.0 kg) completed three sessions, consisting of three trials, separated by one week. Pearson correlation coefficients were used to determine the strength of association between variables, and absolute and relative consistency was assessed using coefficients or variation (CV) and intraclass correlation coefficient (ICC), respectively. Correlations between variables ranged from 0.28 to 0.94, with the 180-degree turn having the greatest shared variance (R^2 = 88.4%) with total time. The greatest shared variance between sub-phases was 68.9% between deceleration and reacceleration 2 and was the only variable to explain more than 50% of shared variance between sub-phases. All CVs were less than 10% and all ICC's were greater than 0.77 indicating acceptable absolute consistency and 'good' to 'excellent' relative consistency. These findings suggest firstly that these sub-phases are all independent qualities, and therefore should be measured as such. Secondly, this advanced diagnostic protocol can measure each of these sub-phases reliably.

1. Introduction

The ability for an athlete to perform a change of direction (COD) is an important physical quality in many team sports, including, soccer (Little & Williams, 2003), volleyball (Gabbett & Georgieff, 2007) and netball (Chandler, Pinder, Curran, & Gabbett, 2014). For example, in netball, a player performs on average 64 COD manoeuvres (Fox, Spittle, Otago, & Saunders, 2014), and a top-class soccer player performs, on average, 726 changes of direction during a match (Bloomfield, Polman, & O'Donoghue, 2007). Due to this high volume of direction changes performed by athletes, it is important to have valid and reliable tests to measure an athlete's COD ability.

The modified 5-0-5 (beginning from a stationary start 0.5 m behind the first timing gate) COD test is one such test used to assess an athlete's ability to rapidly accelerate, decelerate, turn 180-degrees and reaccelerate again. These physical qualities are important for most multidirectional sports (Dos' Santos, McBurnie, Thomas, Comfort, & Jones, 2020). Traditionally, the modified 5-0-5 COD test uses one set of timing gates to assess an

individual's ability to sprint 5 m, perform a 180-degree COD and sprint 5 m back through the timing gates. This test produces a total time (s) for the athlete's performance; however, this test does not provide insight into the performance of the different phases/qualities listed previously.

To provide more useful information to practitioners, it would be beneficial to have measures that differentiate between the different phases of the modified 5-0-5 COD test (acceleration, deceleration, 180-degree turn and reacceleration). Total time may give some insight into COD performance; however, it fails to provide an isolated measure of each phase. For example, an athlete may have great acceleration and poor 180-degree turn ability, but still produces a good total time. Knowing the contribution of each phase will provide higher levels of diagnostics to better inform COD speed development and programming. Similar research has been conducted by Forster and colleagues (2021) for the pro-agility COD test with male high school athletes. The test was adapted, with the addition of timing gates 1 m from each COD line, enabling acceleration, deceleration, and COD performance to be isolated. The authors of this study

reported acceptable absolute consistency (coefficient of variation [CV] <10%) for nearly all variables and 'poor' to 'good' relative consistency for all variables from days 1-2 and days 2-3 comparisons (intraclass correlation coefficient [ICC] = 0.13 to 0.86). The acceleration 2 and 4 split had the highest variability for both day 1-2 and 2-3, however the COD 1 split had the lowest relative consistency (ICC = 0.13). It is of importance to explore both absolute and relative consistency, to get a full understanding of a test's reliability (Hopkins, 2000). Similar procedures should be explored for the modified 5-0-5 COD test to provide greater diagnostic value.

If there is a high degree of shared variance between phases of the modified 5-0-5 COD test, then there is not a solid rationale for separately measuring these athletic qualities. Therefore, the first purpose of this study was to determine the strength of the relationship between the different sub-phases of the modified 5-0-5 COD test. If these sub-phases have a shared variance (R^2) lower than 50%, then the qualities are thought to be reasonably independent of each other (i.e., there is more unexplained variance than explained variance) and therefore it needs to be established whether these sub-phases can be measured accurately and consistently. Thus, quantifying the variability associated with the sup-phase analysis provided the second purpose of this article.

2. Methods

2.1. Experimental approach to the problem

Ten elite female netball athletes performed three maximal effort trials (each leg) of the modified 5-0-5 COD test, over three testing occasions, separated by seven days. Timing lights were placed at 0, 2 and 4 m and the start line was placed 0.5 m back from the first timing gate, to accommodate for a forward lean and eliminate false triggering of the timing lights. This enabled five distinct sub-phases to be established in order to more accurately detect acceleration, deceleration, and COD performance. Shared variance was established via coefficients of determination. The variability of the sub-phases/qualities were quantified using CVs and ICCs.

2.2. Participants

Ten elite female netball athletes (age: 24.9 ± 5.0 years, height: 180.1 ± 6.5 cm, weight: 81.3 ± 15.0 kg) participated in this study. Athletes competed in the New Zealand netball premiership league and had a minimum of six years netball experience. Participants were required to be healthy and free of injury at the time of testing. All participants were provided with an information sheet and were required to fill out a written consent form prior to participating in this study. Participants were notified that they were free to withdraw from the study at any point. This research was approved by the Auckland University of Technology Ethics Committee (20/402).

2.3. Measures

Dual beam timing gates (Swift Performance Equipment, New South Wales, Australia) were used to quantify COD performance. Gates were set at 0, 2 and 4 m to isolate the phases of the 5-0-5 COD test (acceleration, deceleration, 180-degree turn and reacceleration). These distances were piloted, and the authors found that if the last timing gate was any closer to the turn line, then subjects body parts would prematurely break the timing gates. Timing gate height was set at 1 m, in approximate line with centre of mass. This set up produced five different splits, as well as total 5-0-5 COD performance time. These times corresponded to the different phases of the modified 5-0-5 COD test as outlined in Table 1.

Testing was conducted on an indoor netball court. Athletes were instructed to wear the same clothing and footwear for all three sessions. The athletes perform the modified 5-0-5 test on a weekly basis as part of their normal programming and therefore did not require a familiarisation session. Testing was conducted seven days apart, at the same location and time of day. Each testing session was 40 minutes and athletes performed a standardised warm up consisting of lower body activation such as banded walks and squats, a series of different jumps (vertical and horizontal bilateral and unilateral countermovement jumps), dynamic flexibility of the hamstrings, quads, hips and calves, and progressive sprint (5, 10 and 20 m) and COD drills, building the intensity up to maximum effort.

Table 1: The different splits in the modified 5-0-5 COD test and the name and explanation of the sub-phase.

Split	Name	Explanation	Quality
1	Acceleration	From start line to first timing gate (2 m)	Concentric first step quickness
2	Deceleration	From second timing gate to third timing gate (2 m)	Eccentric strength and SSC
3	180-degree turn	One step before and after the 180-degree turn. From third timing gate to turn line (2 m)	Lateral reactive strength (SSC) and isometric strength
4-5	Reacceleration	From third timing gate to finish (4 m)	Concentric strength and SSC
1-5	Total time	5-0-5 COD test total time (10 m)	All qualities

2.4. Procedures

For the modified 5-0-5 COD test, athletes were required to start 0.5 m back from the first timing gate. Athletes were instructed to sprint 5 m and touch their foot on or over the COD line, perform a 180-degree turn on a specific leg and sprint 5 m back through the first timing gate. Three trials within each testing session were performed on each leg. Three minutes of rest was provided between trials to limit any fatigue effects. Athletes were instructed to begin behind the start line in a two-point stance and could begin the test whenever they were ready. To ensure each athlete touched the line, the researchers observed each trial. If the athlete had a mistrial, they were given a retrial after three minutes of rest.

2.5. Statistical Analysis

As there were no significant differences found between left and right COD times, the data was pooled, and all analyses thereafter was performed on the averaged data. Outlier and normality analysis was implemented on the pooled data and means, and standard deviations were reported for all variables of interest, with 95% confidence limits (CL) used where appropriate. Pearson correlation coefficients were used to determine the strength of association between variables and coefficients of determination (R^2) were used to quantify shared variance. Absolute consistency between sessions was quantified using CV, where measures less than or equal to 10% were deemed acceptable (Uthoff, Oliver, Cronin, Winwood, & Harrison, 2018). Relative consistency between sessions was determined using ICC using a two-way random average measures model (Koo & Li, 2016). Classification of ICC was deemed as follows: 'very poor' (< 0.20), 'poor' ($0.20 - 0.49$), 'moderate ($0.50 - 0.74$), 'good' ($0.75 - 0.90$) or 'excellent' (> 0.90) (Buchheit & Mendez-V., 2013). Statistical analysis was performed using IBM SPSS statistical software package (version 27.0, IBM Corporation, New York, USA).

3. Results

The strength of association between each split for the modified 5-0-5 COD test are presented in the correlation matrix (Table 2).

Correlations between variables ranged from 0.28 to 0.94. In terms of the relationship with total time, the 180-degree turn had the greatest shared variance ($R^2 = 88.4\%$) whereas the lowest shared variance was during the reacceleration phases ($R^2 = 42.2\%$). Correlations between sub-phases ranged from 0.28 to 0.83. The greatest shared variance between the sub-phases was 68.9% between deceleration and reacceleration 2 and was the only variable to explain more than 50% of shared variance between sub-phases. The lowest shared variance, (7.8%) was between reacceleration 1 and reacceleration 2.

The inter-session variability of split times and total time for the modified 5-0-5 COD test can be observed in Table 3. The average change in mean (0.35%) between days was 1.08% (days 2-1) and 1.43% (days 3-2). There appeared no systematic change between the variables, the largest change was observed between days 3-2 for the reacceleration 2 phase (-2.4%). In terms of absolute consistency, all CVs were less than 10% (1.1 – 6.6%) the greatest variability found in the 180-degree COD. With regards to rank-order consistency, all but one variable had ICC's greater than 0.77, the lowest relative consistency found in reacceleration 1.

4. Discussion

The purpose of this study was to firstly, determine the strength of inter-relationship between the sub-phases of the modified 5-0-5 COD test, and to determine whether any of the sub-phases were better predictors of COD total time. Also, we wanted to quantify the inter-relationship between sub-phases to determine if they were relatively separate motor qualities. A secondary aim was to determine the variability of the sub-phase qualities. The main findings were: 1) the 180-degree had the greatest shared variance with total time ($R^2 = 88.4\%$); 2) only one of the correlations between sub-phases explained more than 50% of the shared variance (i.e., deceleration and reacceleration), indicating that these sub-phases are for the most part measuring relatively independent neuromuscular qualities; and, 3) in terms of percent change in the mean, absolute consistency and relative consistency, no systematic bias was observed and most of the measures very stable between testing occasions.

Table 2: Pearson correlations (r) between the splits for the modified 5-0-5 COD test.

	Acceleration	Deceleration	180-degree Turn	Reacceleration 1	Reacceleration 2	Total
Acceleration	1.0					
Deceleration	0.65*	1.0				
180-Degree Turn	0.67*	0.59	1.0			
Reacceleration 1	0.38	0.34	0.57	1.0		
Reacceleration 2	0.50	0.83**	0.50	0.28	1.0	
Total	0.74*	0.80**	0.94**	0.65*	0.69*	1.0

Note: * p < 0.05, ** p < 0.01

Table 3: Inter-session variability of split times.

Variable	Mean ± SD			% Change in mean (95% CL)		CV (95% CL)		ICC (95% CL)	
	Day 1	*Day 2*	*Day 3*	*Day 2-1*	*Day 3-2*	*Day 2-1*	*Day 3-2*	*Day 2-1*	*Day 3-2*
Acceleration	0.55 ± 0.03	0.55 ± 0.03	0.54 ± 0.02	-0.8 (-2.3 – 3.57)	-1.2 (-0.81 – 1.31)	1.5 (1.0 – 2.8)	2.5 (1.7 – 4.7)	0.94 (0.78 – 0.98)	0.82 (0.44 – 0.95)
Deceleration	0.51 ± 0.03	0.52 ± 0.04	0.51 ± 0.04	2.1 (-1.0 – 5.4)	-1.2 (-3.1 – 0.7)	3.1 (2.2 – 5.8)	1.9 (1.3 – 3.6)	0.84 (0.39 – 0.96)	0.95 (0.78 – 0.98)
180-degree Turn	0.63 ± 0.09	0.64 ± 0.08	0.64 ± 0.09	1.8 (-2.8 – 6.5)	-1.0 (-7.2 – 5.6)	4.6 (3.2 – 8.6)	6.6 (4.5 – 12.3)	0.90 (0.64 – 0.98)	0.78 (0.29 – 0.94)
Reacceleration 1	0.63 ± 0.03	0.64 ± 0.02	0.65 ± 0.05	0.8 (-2.2 – 3.9)	1.7 (-2.4 – 5.8)	3.0 (2.1 – 5.6)	4.1 (2.8 – 7.6)	0.57 (-0.09 – 0.88)	0.77 (0.26 – 0.94)
Reacceleration 2	0.43 ± 0.02	0.43 ± 0.03	0.42 ± 0.03	0.2 (-2.2 – 2.7)	-2.4 (-5.6 – 0.9)	2.4 (1.7 – 4.5)	3.3 (2.3 – 6.2)	0.83 (0.43 – 0.96)	0.78 (0.31 – 0.95)
Total Time	2.75 ± 0.14	2.77 ± 0.17	2.74 ± 0.17	0.8 (-0.7 – 2.2)	-1.1 (-2.2 – 0.0)	1.4 (1.0 – 2.6)	1.1 (0.8 – 2.0)	0.95 (0.79 – 0.99)	0.97 (0.88 – 0.99)

An interesting finding was that 180-degree turn was the best predictor for total time, which indicates that having good COD ability is the main factor for producing a good modified 5-0-5 total time. Previously it had been suggested that an athlete with good linear speed, but poor COD ability could perform well in a traditional 5-0-5 COD test as their linear sprinting ability could mask any COD deficiencies (Nimphius, Callaghan, Spiteri, & Lockie, 2016), given the greater proportion of time linear sprinting in that test. It would seem from the results using elite netball female athletes that the modified 5-0-5 may be a truer measure of COD ability given the effects of linear speed seem of lesser magnitude.

From the inter-correlations between sub-phases, it is clear that each of the motor qualities were relatively independent of one another, and only one sub-phase explained more than 50% of the shared variance, indicating that each phase for the most part was in fact measuring relatively different neuromuscular capabilities. Reacceleration 2 and deceleration had the greatest shared variance between sub-phases ($R^2 = 68.8\%$). Interestingly, the lowest shared variance was found between reacceleration 1 and reacceleration 2 ($R^2 = 7.84\%$). This suggests that although these two sub-phases are both reacceleration, they are in fact measuring different qualities. The authors hypothesised that reacceleration 1 would require greater concentric strength, whereas reacceleration 2 would be relying on greater reactive strength. To the authors knowledge, this is the first study to perform a sub-phases analysis on the modified 5-0-5 COD test, therefore there is limited literature to compare results with.

A majority of the research on the variability of the modified 5-0-5 COD total time, has focused on within-session variability (Thomas, Comfort, Chiang, & Jones, 2015; Thomas, Dos'Santos, Comfort, & Jones, 2016), however this information is of limited use as it does not indicate whether the test is variable across testing occasions. Barber and colleagues (2016) reported high relative within-session consistency (ICC = 0.97) for the modified 5-0-5 COD test, however they did not report absolute consistency. In this study, total modified 5-0-5 COD time was found to have excellent (ICC = 0.95 & 0.97) relative consistency and acceptable absolute consistency (CV = 1.4% & 1.1%), between days 2-1 and 3-1 respectively. These results were similar to previous research for this test (Barber et al., 2016; Gabbett, Kelly, & Sheppard, 2008).

All sub-phases were found to have good to excellent relative consistency (ICC = 0.77 to 0.98) and acceptable absolute consistency (CVs < 5%), except for acceleration 1 that was found to have moderate (ICC = 0.57) relative consistency between days 2-1. To the authors knowledge, there is currently only one study that has attempted to isolate and determine the variability of different sub-phases for a COD test. Forster and colleagues (2021) measured different components of COD performance during a pro-agility COD test, by including three sets of timing gates. Interestingly, this research reported acceleration 1 to be the only variable with acceptable relative and absolute consistency (ICC = 0.71 to 0.79, CV = 5.16 to 5.39%). It was suggested that this may be because reacceleration phases may be influenced by COD, as post-COD acceleration or reacceleration can be influenced by the body and force orientation (Dos'Santos, Thomas, Comfort, & Jones, 2018). This may have been the case for this research, as the reacceleration 1 phase was shown to have the lowest absolute and relative consistency (CV = 3.0% and 4.1%, ICC = 0.57 and 0.77),

however these values are still acceptable and considered reliable. There was very little systematic bias between sessions, however, it needs to be noted that the participants were elite athletes that performed the modified 5-0-5 test on a regular basis and did not require any familiarisation.

4.1. Conclusion and Practical Applications

It appears that the modified 5-0-5 COD test can successfully be split into sub-phases, and each sub-phase can be measured consistently using dual-beam timing gates. It is clear that these sub-phases are relatively independent qualities, and therefore should be measured as such. Although educated guesses can be made as to which neuromuscular qualities are most at play during these sub-phases, further research is needed to solidify this. Furthermore, readers should be cognizant that the findings of these results are specific to well-trained netball athletes, and more research is needed with different athletic populations. This advanced modified 5-0-5 COD diagnostic protocol can enable strength and conditioning coaches and sports scientists to reliably track sub-phase performance and identify areas of strengths and weakness of their athlete, thereby providing specific information related to athletes which can be used for training specificity. Intuitively this should improve COD performance, however, such a contention needs to be validated using longitudinal designs.

Conflict of Interest

The authors declare no conflict of interests.

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