Relationships between movement quality, maturation, strength and asymmetry in sub-elite adolescent rugby union players.

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ABSTRACT

Adolescent male rugby union players (n=22) from King Edward's Bath School (age, 15.8 ±1.0 years; stature, 179.4 ±7.0cm; and mass, 73.2 ±10.7 kg) were evaluated using the conditioning specific movement tasks (CSMT) assessment. Data allowing the estimation of peak-height velocity (PHV) were used to measure maturation offset score (MOS). Participants had bilateral (Bi)and unilateral (Uni) symmetry measured through mid-thigh isometric pull (MTIP) testing. Imbalances in Bi and Uni symmetry were calculated using a symmetry index (SI) and paired samples t-tests; comparisons were made between left(L) and right (R), and dominant (D) and (ND) limbs. Pearson correlations revealed a strong positive correlation between CSMT scores and body mass (r=0.53); moderate correlations were found between CSMT scores and Bi mean MTIP force (r=0.42), Bi D vs ND SI (r=-0.49) and MOS (r=0.32). Linear regression revealed that performance in the CSMT was predicted by the overhead squat (OHS) (p= 0.00001, r= 0.78), single-leg squat (SLS) (p= 0.031, r=0.56) and counter movement jump (CMJ) (p=0.0004, r= 0.66). Participants were grouped into a high competence (HC) (n=5), medium competence (MC)(n=8) and low competence groups (LC)(n=9) according to performance in these movements. ANOVA analysis revealed that the HC group: had significantly higher body mass, and strength levels than both other groups, and were significantly more mature than the MC group. The HC group were also the only group not to have significant Bi differences between D and ND limbs. These data suggest that variables assessing movement quality, maturation, strength and symmetry are closely related in sub-elite adolescent populations.

KEY WORDS: Unilateral, Bilateral, Mid-Thigh Isometric Pull, Conditioning Specific Movement Tasks, School.

CHAPTER 1: INTRODUCTION

Strength and conditioning programs are increasingly becoming part of school physical education programs and in grass-roots sports participation (18). Furthermore, school and club team-sports programs, and organising bodies, have increasingly recognised that strength and conditioning programs have become a necessary part of the ways in which they can protect the welfare of the children in their care, especially in contact sports such as rugby union (21,24,44). Although most of the injuries sustained by youth athletes are incurred during match play (22), it has been suggested that training activities might account for up to 20% of the injuries (44). Research has previously found that higher playing level has been linked to increased risk of injury (7), but in adolescent populations it has been suggested that school players have higher injury rates than academy players (44). The nature of the injuries sustained by school players suggests that coaches and teachers seeking to reduce the injury risk to school players should prioritise the coaching of technical skills involved in scrummaging, weight-lifting and fundamental movement skills (44). Parsonage et al.'s (2014) conditioning specific movement tasks (CSMT) assessment appraises the type of movements to which academy, and increasingly school-level, players are exposed in training and seems an appropriate way in which to assess the movement of adolescent rugby union players (45). However, its use has only been recorded once in the literature and it was not to applied to a sub-elite school based playing population. This study, therefore, will add to the limited body of literature on both the CSMT assessment and school-level playing populations by examining its relationship with several variables which have been shown to correlate with movement quality and performance in adolescent populations.

Movement quality is a priority for strength and conditioning coaches working with youth athletes (6). However, at the time of writing there is still not: an agreed definition of the term; a consensus

on an appropriate objective measure of movement skill in young athletes; nor a body of scientific literature to affirm its value in sports performance for this population (33,37,45). Indeed, the stated intent for many assessments of movement quality is the purported reduction of injury risk; however, none of the assessments available have the requisite evidence to be seen as injury prediction tools (33). The relationship between movement quality, physical capacities and sports performance is an area in which a significant amount of study must be made before any firm conclusions can be drawn (37). However, the available evidence suggests that these variables may be related, especially in adolescent populations. McGill, Anderson and Horne (2016) found some evidence to suggest that markers of movement quality (as defined by the terms of their study) were linked to some performance variables in elite basketball players (34). McKeown (2013) has also established some preliminary evidence for links between movement quality, as measured by his Athletic Ability Assessment (AAA), power production and reduced injury risk in junior athletes (37). It also seems noteworthy that Functional Movement Screen (FMS) scores have been seen to improve after traditional resistance training (6); suggesting that general qualities such as strength might have a relationship with movement quality, as it was defined by the FMS. Parsonage et al. (2014) have suggested that movement quality, as measured by their CSMT assessment, correlates to performance in a battery of physical fitness tasks in talent identified young rugby players moving into the “train to compete” stage in the LTAD model (45). However, beyond this, there is little evidence available to detail the nature of the relationship between movement quality and markers of physical performance. There is, therefore, a need for researchers to investigate this relationship and to build on previous research in this area.

As with much the literature available to date, movement quality will be defined by the movement assessment used to quantify it (5,2834,43, 45,47). The CSMT assessment examines the movement patterns which underpin many of the gym and field based sessions in which young athletes participate; jumping, landing, sprinting, and lifting (45). As such, it is an ecologically valid assessment for strength and conditioning practitioners working with sub-elite adolescent rugby union players.

As yet, only Parsonage et al. (2014) have recorded its use in scientific literature, therefore, in order to examine its value as tool, this study aims to build on their work by exploring some of the limitations of their investigation. Parsonage et al. (2014) found that they were able to best discriminate between participants based on their performance in the squat related tasks of the CSMT; the researchers divided them into the following categories: The 'Squat Competent' (SC) group, who were competent across all measures of the CMST and were best in the OH Squat and SL Squat Tasks; the 'Squat Low Competent' (SLC) group, who were competent in all CMST measures except for the OH and SL squat tasks; and the 'General Low Competent' Group, who returned the poorest scores across all CMST measures. Parsonage et al.'s (2014) results state that there were no statistically significant anthropometric differences between the groups (45). However, the mean body mass for the SC group was 66.7(±7.7) kg, whereas for the SLC and GLC groups it was 73.8 (±11.2) and 72.0 (±14.3) respectively (45). Although the statistical analysis of the data found no significant differences between the body masses of the groups, it could be argued that the practical differences between the groups warrant further investigation of body mass as a performance variable, especially in light of literature of the topic (13,15,18,20). Researchers finding such practical discrepancies between groups in adolescent populations have advised caution in the interpretation of their results (15). Furthermore, research dealing with similarly talent identified populations have found that that some of the physical tests used in Parsonage et al.'s (2014) work favoured lighter athletes over heavier ones: the yo-yo level 1 intermittent recovery test, the counter movement jump, and linear sprinting are all in tests in which athletes with relatively lower bodyweights were more successful (13,18, 20). However, contrarily, a large body of literature dealing with adolescent populations has also strongly associated increases in biological maturation and body mass with increases in measures of performance (8,9, 28, 32, 46, 50). These inconsistencies warrant that close attention is paid to body mass as a variable in measures of performance and movement quality. It is not being suggested here that Parsonage et al. (2014) were incorrect in their statistical calculations and in the interpretation of their results, only that in light of the literature available, the relationship

between anthropometric, maturation measures and CSMT scores, alongside the other variables being measures, will be closely examined.

Strength is a foundational physical quality which underpins performance in many other physical tasks, especially in adolescent populations (2,18,23,26,35,36,39,48,49,53). Although there are many ways in which it could be assessed (38), here, the mid-thigh isometric pull (MTIP) will be used for three reasons. Firstly, scores on MTIP have been correlated to performance in many measures of physical capacity (2, 14, 49, 53). It should, therefore, give an indication not only of the strength of the athletes, but also an indication of overall athletic capacity. Secondly, it is a safe, replicable and logistically practical means of assessment which will allow all participants to express their strength. Other methods, such as the barbell based strength movements may not carry higher injury risks for novices and will allow those who are more technically accomplished to record relatively higher scores (12, 18, 27, 51). Thirdly, the use of MTIP will allow the measurement of both bilateral and unilateral symmetry. Bilateral asymmetry has been linked to FMS scores and overall likelihood of injury (41). It has also been related to measures of physical performance in adolescent populations (16). Therefore, given the previously established relationship with markers of movement quality and physical performance, it seems likely that bilateral and unilateral asymmetry will affect the performance of adolescent athletes. No studies have assessed unilateral MTIP is adolescent populations, thus the study will give some novel insights into the relationship between asymmetry, strength and movement quality in this population.

The primary aim of this research is to investigate which variables have the strongest relationships with movement quality in adolescent populations. As secondary aims: the CSMT movements which best predict overall CSMT performance will also be investigated; as will the differences between groups at various levels of competence in the CSMT key markers. It is hypothesised that: all of the variables under study will have strong to moderate correlations with CSMT performance; that, in line with Parsonage et al.'s (2014) work, the overhead squat (OHS) and single leg-squat tasks (SLS) will

best determine overall performance in the CSMT assessment; and that athletes exhibiting higher levels of strength, biological maturation and body mass, and lower levels of asymmetry will record higher scores in the CSMT assessment.

CHAPTER 2: METHODS

Experimental Approach to the Problem

Over a 4-week period, adolescent rugby players from King Edward's School Bath completed bilateral and unilateral MTIP and CSMT assessments. Anthropometric data allowing the estimation of maturation were also recorded. The MTIP has been validated as being a reliable indicator of strength, especially in the deadlift and squat (14, 16, 25). It was used here as it allowed participants to express force in a way which was safe and replicable. All CSMTs were captured by video and assessed qualitatively according to the criteria defined by Parsonage et al. (2014).

Subjects

Prior to making contact with any potential subjects, the research proposal was reviewed and received ethical approval from the School of Sport, Health and Applied Sciences Ethics Committee of St. Mary's University, Twickenham. Of the 60 potential subjects to whom the study was presented, 22 adolescent male rugby union players (age, 15.8 (±1.0) years; stature, 179.4 (±7.0) cm; and mass, 73.2 (±10.7) kg), who had all played 'A' team rugby union in their respective year groups, agreed to participate. Players and parents received detailed written information relating to the study. Subjects could only participate in the study once informed consent had been given in writing by both the potential subject and their parent/guardian.

Procedures

All testing took place over a four-week period in March and early April at King Edward's School, Bath. The first two weeks were used to collect strength and anthropometric data. After these data were collected, the CSMT data were then collected in the next 2 weeks. All participants were students at the school and signed up for a data collection slot at a convenient time.

Anthropometric, Strength and Symmetry Data

The participants had their standing height, sitting height, body mass and date of birth recorded to estimate peak height velocity, which was calculated using the Mirwald et al.'s (2002) equation (40). Maturation Offset Score (MOS) was measured by subtracting chronological age from estimated age at peak height velocity (PHV). The participants performed a 5-minute standardised warm-up comprised of calisthenics and dynamic stretching. MTIPs were performed on a power rack (Bodymax CF375 Power Rack, BodyMax, UK), with participants pulling at 20kg barbell (York Barbell Company, York, PA, USA) into pins which could be adjusted at 3cm intervals. The rack was weighed down with 300kg in order to ensure that participants could not move it during their MTIP attempts. Participants were given a demonstration of correct technique for the MTIP, and bar height was adjusted for each participant to ensure that the bar rested just below the crease of the hip (16). Participants adopted a self-selected position from which to pull, as it has been established that differences in knee and hip joint angles during MTIP do not significantly affect performance (11). Participants were allowed 2 practice pulls at a self-selected intensity before their recorded attempts. The participants performed 6 pulls in total: 2 bilateral pulls in which the force through both feet was measured using two separate force plates; 2 unilateral pulls on their right leg; and 2 unilateral pulls on their left leg. As per previous protocols (17), participants were given a 3 second count down ending with the command 'Pull', after which they pulled as hard as possible for 5 seconds. Verbal encouragement was given to the participants during the pull. Each participant was given a 2-minute rest period between recorded MTIPs. A dice was used as a random number generator to ensure that the order of the pulls was random and did not have any bearing on the overall results. MTIP data were recorded by Pasco force plates (PS 2142, Roseville, Calif; 1000Hz sampling rate). Symmetry between left (L)and right (R), and between dominant (D)and non-dominant (ND) limbs was calculated by the formulae (right leg – left leg/ right leg × 100) (17,42). The D limb was deemed to be that which produced the highest mean force.

Conditioning Specific Movement Tasks

The participants performed a 5-minute standardised warm up comprised of calisthenics and dynamic stretching. The 6 CSMT were; counter movement jump (CMJ), double leg-single leg landing (DL-SL), single leg squat (SLS), Romanian deadlift (RDL), overhead squat (OHS) and sprint. The tasks were always performed in that order, to the specifications set out by Parsonage et al. (2014). Participants were given a standardised demonstration of each movement pattern and were allowed 3 practice repetitions of each movement. Recorded movements were simultaneously filmed from the front and from the right-hand side using King Edward's School iPad 2s (Apple, Cupertino, CA, USA). The sprint was only filmed from the front, with the data between 20-40m being analysed. Verbal cues were given to each subject in between the 2 recorded repetitions. Unilateral movements were performed on L limbs first. All video data was transferred to the King Edward's School network where it was stored for analysis. The data were independently analysed by two members of King Edward's school staff, one of whom re-examined the data two weeks later. The CSMT scores were calculated using the Parsonage et al.'s method (detailed in Table 1).

Table 1: Parsonage et al.'s (2014) scoring criteria for CSMT movements.

Score	OH Squat	RDL	SL Squat	DL-SL Landing	Sprint	CMJ
3	Hip/Knee/Ankle aligned Upright Trunk Heels Flat Depth ≥ 90 Bar Controlled/elbows locked out	Neutral Spine Knee Flexion maintained (~15) Synchronicity of movement	Hip/Knee/Ankle aligned Pelvis Horizontal Upright Trunk Heels Flat Depth ≥ 90 Balanced	Hip/Knee/Ankle aligned Pelvis Horizontal Upright Trunk Heels Flat Landing Stuck	Hip/Knee/Ankle aligned Pelvis Horizontal Limb symmetry No arm rotation	Hip/Knee/Ankle aligned Upright trunk Full triple extension Counter movement
2	Hip/Knee/Ankle aligned Heels Flat Depth < 90 Bar in front of Head Bar not controlled/elbows not locked out	Neutral Spine Knee flexion not maintained Movement not synchronised	Hip/Knee/Ankle aligned Heels Flat Balanced Pelvis is not horizontal Trunk not upright Depth < 90	Hip/Knee/Ankle aligned Landing Stuck Pelvis not horizontal Trunk not upright Heels not flat	Hip/Knee/Ankle aligned Pelvis not horizontal Limb asymmetry Arm rotation across body	Hip/Knee/Ankle aligned Counter movement Trunk not upright Lack of triple extension
1	Hip/Knee/Ankle not aligned Heels not flat More than 2 compensatory movements	Neutral spine is not maintained More than 1 compensatory movement	Hip/Knee/Ankle not aligned Heels not flat More than 2 compensatory movements	Hip/Knee/Ankle not aligned Landing not stuck More than 2 compensatory movements	Hip/Knee/Ankle not aligned More than 1 compensatory movement	Hip/Knee/Ankle not aligned No countermovement More than 1 compensatory movement

Statistical Analyses

Statistical calculations were made using IBM SSPS version 22 (SSPS, Chicago, Ill, USA) and Microsoft Excel (Microsoft, Reading, UK). Descriptive statistics were reported for all CSMT, strength and anthropometric data. Re-test and inter-rater reliability were established using Kappa statistics. Paired samples t-tests were used to compare bilateral and unilateral scores between L vs R and D vs ND limbs. Pearson correlations were calculated to examine relationships between variables. A multiple linear regression was used to determine which movements contributed most significantly to overall CSMT scores. A one-way ANOVA with Bonferroni post-hoc testing was used to compare groups determined by CSMT scores. Paired samples t-tests were used to compare bilateral and unilateral D vs ND MTIP readings within groups. Statistical significance was set at $p < 0.05$.

CHAPTER 3: RESULTS

Inter and intra-rater reliability scores for all CSMT data are reported in Table 1. All CSMT's displayed at least a moderate level of agreement, with most rated good or above. The cohort performed best on the CMJ, RDL and Sprint tasks; the participants performed less successfully on the landing and squatting tasks (see Table 2).

A strong positive correlation was found between CSMT scores and body mass (r=0.53), and moderate correlations were found between CSMT scores and bilateral mean MTIP force (r=0.42), bilateral D vs ND SI (r=-0.49) and MOS (r=0.32) (see table 4). Weak correlations were found between CSMT scores and relative mean force (r=0.25) and unilateral D vs ND SI (0.13). Other strong correlations were found between body mass, bilateral MTIP Mean Force (r=0.59), and MOS (0.78). Relative mean force was also strongly related to Mean MTIP force (0.78). Moderate relationships were found between: unilateral SI and body mass (r=-0.36); and bilateral MTIP Mean Force and maturation offset score (0.47).

A multiple linear regression of the CSMT data found that the movements which best predicted overall performance on the CMST were the OHS (p= 0.00001, r= 0.78), SLS (p= 0.031, r=0.56) and the CMJ (p=0.0004, r= 0.66). Participants were then ranked and grouped according to the percentile into which they fell based on performance in these measures, as detailed in Table 5. Significant differences were found across all groups in body mass (p=0.008) and strength (p=0.015) The HC group also had a significantly higher MOS score than the MC group (p=0.049). No significant differences were observed in the SI scores between groups.

Across the cohort, significant differences between L and R were observed bilaterally (p= 0.03806), but not unilaterally (p=0.7502)). However, significant differences were observed between D and ND limbs both unilaterally (p= 0.0004) and bilaterally (p=0.0001). All the groups exhibited significant differences between D and ND limbs, both unilaterally and bilaterally, except for the HC group who had no significant bilateral differences between D and ND limbs.

Table 2: Inter-rater and intra-rater reliability for CSMT scores.

CSMT Movement Task	Inter-rater		Intra-rater	
	Kappa	Level of Agreement	Kappa	Level of Agreement
CMJ	0.645	Good	0.794	Good
SL Landing L	0.476	Moderate	0.582	Moderate
SL Landing R	0.633	Good	0.639	Good
SL Squat L	0.842	Very Good	0.92	Very Good
SL Squat R	0.609	Good	0.697	Good
OH Squat	0.643	Good	0.788	Good
RDL	0.796	Good	0.859	Very Good
Sprint	0.569	Moderate	0.836	Very Good

Table 3: Distribution of frequencies for each mark on the CSMT given as %.

%	CMJ	Landing L	Landing R	SLS L	SLS R	OHS	RDL	Sprint
1	27	45	45	50	50	45	27	32
2	23	50	55	41	36	27	45	55
3	50	5	0	9	14	27	27	14

Table 4: Pearson Correlations between all variables.

	CSMT	Strength	Relative Strength	Bilateral SI (D vs ND)	Unilateral SI (D vs ND)	Body Mass	MOS
CSMT	1.00						
Strength	0.42	1.00					
Relative Strength	0.25	0.89	1.00				
Bilateral SI (D vs ND)	-0.49	-0.13	0.05	1.00			
Unilateral SI (D vs ND)	0.13	-0.25	-0.11	0.00	1.00		
Body Mass	0.53	0.59	0.17	-0.36	-0.36	1.00	
MOS	0.32	0.47	0.12	-0.25	-0.16	0.78	1.00

Table 5: CSMT Performance Groups and associated anthropometric, strength, and symmetry data.
Significantly different to MC at $p \leq 0.05$. Significantly different across all groups at $p \leq 0.05$.

	Movement/Variable	HC Group (n=5)	MC Group (n=8)	LC Group (n=9)
CSMT (% of group who scored 2 or above)	CMJ	100	87.5	44
	Landing L	40	62.5	56
	Landing R	60	50	56
	SL Squat L	80	62.5	22
	SL Squat R	100	50	22
	OH Squat	100	75	11
	RDL	80	50	89
	Sprint	60	100	44
CSMT, Anthropometric, Strength and Symmetry Data	Key CSMT	10.2 ± 1.5	7.8 ± 0.4	5 ± 0.8
	Age (yrs)	16.6 ± 0.5	15.4 ± 1.0	15.7 ± 0.9
	Weight (kg)	85.4 ± 4.6	69.2 ± 9.3	70.0 ± 8.6
	MOS (yrs)	2.0 ± 0.5	0.7 ± 1.0	1.0 ± 0.7
	Strength (Mean Bilateral MTIP) (N)	1169.1 ± 252.5	749.7 ± 114.1	811.8 ± 265.7
	Relative Strength (kg/kg)	1.4 ± 0.3	1.1 ± 0.2	1.2 ± 0.3
	Unilateral SI (D vs ND) (%)	3.7 ± 1.4	14.1 ± 13.4	5.5 ± 2.8
	Bilateral SI (D vs ND) (%)	25.7 ± 24.9	22.4 ± 11.5	36.2 ± 24.6
	Unilateral D vs ND Difference (p)	0.0058	0.0300	0.0007
	Bilateral D vs ND Difference (p)	0.1348	0.0020	0.0084

CHAPTER 4: DISCUSSION

The aim of the study was to investigate the relationship between movement quality, strength, maturation and symmetry in adolescent rugby union players. The predictions of the hypothesis were largely confirmed by the data: body mass, bilateral symmetry index, strength and maturation had strong and moderate relationships with CSMT scores; the OHS, CMJ and SLS best predicted overall CSMT performance. The HC group; were significantly stronger and heavier than both other groups; were more biologically mature than the MC group; and had no significant bilateral difference between D and ND limbs. However, a relationship between relative strength and movement quality did not materialise in the way that was expected. Although relative strength is a desirable physical characteristic for many athletes, especially those playing field sports (4), the results of this study affirm the broader findings of the literature on adolescent populations; heavier, more biologically mature, adolescent athletes perform better in fitness measures and movement quality (8,9, 28, 32, 46, 50).

The results of Parsonage et al. (2014), in which lighter athletes performed better in the CSMT and in fitness measures, might be explained by differences in the populations under study. Parsonage et al.'s (2014) cohort were selected from a talent identified population who were potential future elite players, whereas the participants in this study had represented their school 'A' team. In similarly talent identified populations in football, it was found that players born in different quartiles of the year exhibited no significant differences in maturation offset scores, anthropological characteristics, nor in scores for tests in physical fitness (15, 29). As yet, no data exists within rugby union to confirm this hypothesis, however, these results arguably suggest that in talent identified populations biological maturation does not differentiate performance in the same way that it might do in populations derived from school teams. It could even be hypothesised that 'talent identified' populations are 'identified' as such due their higher levels of biological maturity (15, 32). However, as mentioned above, Deprez et

al. (2013) did advise caution in the interpretation of their data based on the practical differences they found between their groups (15). Nevertheless, given that 'talent identified' populations might not necessarily exhibit significant differences in biological maturation and anthropological characteristics, it stands to reason that relative strength might better differentiate performance between athletes. Indeed, studies which have controlled for body mass still see significantly different results in scores across markers of physical performance in talent identified adolescent populations (39). It has also been shown that maturation has more of an effect on anthropological and fitness measures than it does on motor coordination skills (16) (52). Although increases in body mass are undoubtedly significant in adolescent populations, other markers of performance can still differentiate between athletes, especially in talent identified populations. As mentioned above however, there is, as yet, no such data describing talent identified adolescent rugby union players to verify this.

In line with previous research, this study suggests that imbalances between D and ND limbs are more significant than those between L and R (16). In this study, only the HC group displayed no significant differences between D and ND limbs when pulling bilaterally. Although these results might indicate a relationship worth investigating further, they also suggest the limitations of the data. Firstly, the size of the HC group was very small (n=5). It remains to be seen whether similar results would be found using larger sample sizes. That said, the results do seem to be in keeping with the limited literature available on adolescent populations. Research has reported larger asymmetries in weaker athletes (1,3,4, 17); which was reflected in this work as the HC group were significantly stronger than both other groups. However, only a weak Pearson correlation was found between mean IMTP scores and bilateral D vs ND SI. Therefore, although the findings of this study seem in line with the available literature, further research is needed, with larger sample sizes, in order to clarify the nature of this relationship.

No data is available on unilateral stance MTIPs on adolescent populations, therefore the findings of this study, despite their relatively low participants numbers, can be seen a starting point for enquiry. The literature investigating unilateral stance MTIP deals with professional rugby league players and collegiate level multi-sport athletes (17) and found that across both populations significant differences were observed between D and ND limbs but no significant differences were observed between L and R. Although this study found significant bilateral differences between L and R limbs, its findings suggest that unilateral imbalances between D and ND limbs might be expected across numerous athletic populations (42). All of the groups exhibited significant differences between unilateral D and ND limbs, and there were no significant differences between groups in unilateral SI scores. D vs ND unilateral SI scores had no strong relationships with any other variable; one moderate negative correlation was with body mass (-0.35), and weak correlations with mean bilateral MTIP force (-0.26) and CSMT Total (0.12). Therefore, although there may be an emergent hypothesis connecting unilateral SI scores, strength and body mass; at this stage, it seems more appropriate to state that unilateral asymmetry can be expected across a number of athletic populations, but its implications for performance are not yet known and require further investigation.

This study, like Parsonage et al. (2014), found that the CMJ, SLS and OHS tasks were the most important predictors of overall CSMT performance (45). The findings of this study therefore contribute to the body of literature evidencing the value of the OHS as a versatile predictive tool. In this study, and in other similar work addressing assessments of movement quality, it was found to be the most significant contributor to overall scores (5,10, 28). Banyard and Wood (2016) found that, in the Athletic Ability Assessment (AAA), the OHS was the test which best discriminated between talent identified and non-talent identified adolescent Australian football players (17.5 ± 0.6 y) (5). Similarly, Clifton et al. (2015) found that the OHS correlated to overall performance in the FMS in collegiate athletes (10) However, although Lloyd et al.

(2015) found the OHS to be a significant predictor of overall FMS performance, they found the in-line lunge to best account for variance in the reactive strength index (28). Thus, although the literature suggests the OHS is a valuable and versatile predictive tool, other movements may also be correlated to measures of performance. The implications of OHS performance for adolescent athletes are not yet clear; however, future research could seek to establish the replicability of the studies in which the OHS predicted the overall score in the movement assessments. Furthermore, its ability to discern between talent identified and non-talent identified groups could be examined and in doing so its relationship with performance related variables could be explored. This study found that those who performed best in key markers of CSMT performance had significantly higher bodyweights, maturation offset scores, and mean strength levels than those whose key movement scores were lower. Although there is still some ambiguity around the relationship between coordination and biological maturity (19, 52), these findings are in line with an increasingly substantial body of literature evidencing the interdependence of these variables in adolescent populations. (8,9, 23, 28, 32, 46, 50).

The differences between the findings of this study of those of Parsonage et al. (2014) warrant further investigation; currently these are the only two studies in the literature to have used the CSMT assessment. Although the results of the inter and intra assessment reliability were mostly good, it could be that these tests were administered using a different interpretation of the available CSMT assessment criteria. In this study, a higher percentage of participants scored 2 or above in the SLSL and SLSR than those in Parsonage et al.'s (2014) study; 50% for both L and R in this study vs 13% and 16% for L and R, respectively. It remains to be seen whether the differences between the studies are due to: the previously stated differences between the populations under study; the results of a relatively small sample size; differences in the way that the tests were administered. Further research will be needed on a variety of athletics populations to clarify the nature of the differences exhibited between these two studies and to

explore the nature and scope of the results which can be obtained from a CSMT assessment. Furthermore, relationships between the CSMT and other indices of maturation may yield different results. The limitations of the equation used in this study have been well established in the literature (30,31); it could be that early or late maturing boys might have recorded different MOS scores had other measures been used.

CHAPTER 5: PRACTICAL APPLICATIONS

Although the small sample sizes of these data limit the scope of its implications, strength and conditioning practitioners working with sub-elite rugby union players could apply several ideas from these data. Firstly, although no movement assessment has been verified as an injury prevention tool (not least the CSMT), the technical nature of the injuries suffered by school level players in training suggests that coaches could benefit from implementing a movement assessment which addresses these specific demands, such as the CSMT. If such an assessment would be too logistically difficult or time consuming, then the OHS, given its strong correlation with overall CSMT performance and its relative value in other movement assessments, might be an effective and efficient substitute. The findings of this study also suggest that coaches aiming to reduce injury risk and improve movement quality, however it is assessed, might also benefit from ensuring their athletes are on a progressive resistance training program designed to improve their strength. Ensuring that such a program promotes symmetry between D and ND limbs, through unilateral training, might also help to promote both movement quality and strength with this population. Coaches applying a movement assessment, such as the CSMT, should also consider the bodyweight and maturation levels of their athletes; lower scores in the movement assessment may be symptomatic of lower body mass and maturation and coaches should therefore exercise caution when comparing movement quality scores between athletes with significantly different body mass and maturation levels.

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St Mary's University Twickenham London

APPENDIX 1: SIGNED ETHICS APPLICATION

SCHOOL OF SPORT, HEALTH AND APPLIED SCIENCES (SHAS)

Research / Dissertation / Project Approval Form – Page 1 of 2

This form contains all the necessary guidance and relevant information links to complete a Research, Dissertation or Project.

A: Research, Dissertation or Project General Information

Name:	Thomas Fisher	Project Tutor/Supervisor:	Dr Daniel Cleather
Reg. no.:	145242	Contact number:	07890390138

Project Proposal title: Is movement quality related to relative strength in adolescent rugby players?

B: Application for Resources (Equipment and Consumables)

Establish the Research, Dissertation or Project cost, by referring to the costing guide located on the simmsCAPtial folder http://simmscapital.smuc.ac.uk/course/view.php?id=8401 . Please note that you must allow adequate time for the ordering and delivery of any approved consumables.

EQUIPMENT APPROVAL SUBJECT TO AVAILABILITY (LIST ALL INTENDED EQUIPMENT TO BE USED):	APPROVAL SIGNATURE:
Video recording equipment. Force plate.	Technical Staff

CONSUMABLES APPROVAL (QUALIFYING CRITERIA):		TICK	REQUIRED ACTION	APPROVAL SIGNATURE
Option 1	Undergraduate project cost is less than £50 Post graduate project cost is less than £100	 Y	Option 1 can be signed by the Tutor/Supervisor.	Tutor/Supervisor
Option 2	The cost is more than the relevant funding limit as detailed in Option 1		Option 2 funding request £……(inc.VAT)	Academic Director

Testing schedule must be agreed prior to RA and Ethics	Tick	
Category 1 – Normal hours (9-5) / daytime subjects	Y	
Category 2 – Apply for extraordinary testing circumstances		***Details of agreed Out of hours / non permitted equipment etc***

C) Completion of a Risk Assessment (to manage all relevant Hazards)

A Practical Risk Assessment Form (PRA1) must be completed for all research, dissertation or project work. A completed PRA1 form will enable the commencement of laboratory or field testing, whether using human subjects (see Section D) or not. Please refer to Student information module on simmsCAPital for assistance, or alternatively contact your tutor or relevant member of the Technical Services Team.

QUALIFYING CRITERIA	REQUIRED ACTION	APPROVAL SIGNATURE
Any practical / testing activity	Complete a SHAS Practical Risk Assessment (PRA1) Form. Once completed, this Section can be signed off by a relevant member of the TS Team.	Technical Staff

Research / Dissertation / Project Approval Form – Page 2 of 2

D) Application for Ethical Approval (including the use of Human Subjects)

An **Application for Ethical Approval Form** must be completed for any Research, Dissertation or project to determine the ethical grading (Level 1, 2 or 3) and relevant approval pathway, as set out in the table below. For forms, guidelines and application dates please see: http://simmspace/about/academic-board/ethics-committee/Pages/default.aspx

	QUALIFYING CRITERIA	TICK	REQUIRED ACTION	APPROVAL SIGNATURE
Ethics Level 1	The protocol matches a School of SHAS Standard Lab Procedure with Ethical Approval		The protocol can be signed off by the relevant Tutor/Supervisor	Tutor/Supervisor
Ethics Level 2	The protocol does not match a School of SHAS Standard Lab Procedure with Ethical Approval	x	The Application for Ethical Approval Form must be submitted to the School Ethics Representative.	Ethics Representative
Ethics Level 3	The Project is deemed to have an Ethics Level 3 status by the School's Ethics Representative.	x		

Additionally, specific forms must be produced for the use of all human subjects who are participating in physical activity, ingesting liquids/foods/supplements and / or receiving treatment, as set out in the table below.

QUALIFYING CRITERIA	TICK	REQUIRED ACTION:	APPROVAL SIGNATURE
All activities using human subjects	✓	Receive a Subject Information sheet., and complete an Informed Subject Consent form. See http://simmspace.smuc.ac.uk/prog-admin/Pages/ethics-and-integrity.aspx Complete a Medical History/ PAR-Q Form. See simmsCAPital http://simmscapital.smuc.ac.uk/course/view.php?id=8401	Tutor/Supervisor

All Consent and Screening Forms must be counter signed/dated and retained by (you) the test coordinator during the testing phase, and then returned to the Tutor/Supervisor for data protected archiving. The table below clarifies which forms are relevant and what action to take.

E) Competency training and authorisation to undertake specific testing activities

Approval to competently undertake the intended protocol(s) must be obtained through the student completing training, practice and passing an assessment . Specific approval forms may need to be completed. Tutors must attend the first pilot/testing session to jointly (tutor/student/technician) approve the relevant protocol and student competency. Please note that further practice may be required if competency cannot be demonstrated. Please see Technicians for more information.

ACTIVITY REQUIRING APPROVAL	RELAVANT INDUCTION OR FORM	APPROVAL SIGNATURES	
Physical activity testing	Student passed practical skills module	Technician	Tutor/Supervisor

F) Research/Dissertation/Project declaration

In undertaking my Dissertation/Research Project, I agree to adhere to the approved guidelines and procedures for the protocol I am using, and will inform my supervisor of any necessary changes to my protocol.

DECLARATION SIGNATURE: T. [illegible] (*...the relevant Research/Dissertation or Project)*

DATE: 6/12/2016

St Mary's University Twickenham London

St Mary's University

Ethics Sub-Committee

Application for Ethical Approval (Research)

This form must be completed by any undergraduate or postgraduate student, or member of staff at St Mary's University, who is undertaking research involving contact with, or observation of, human participants.

Undergraduate and postgraduate students should have the form signed by their supervisor, and forwarded to the School Ethics Sub-Committee representative. Staff applications should be forwarded directly to the School Ethics Sub-Committee representative. All supporting documents should be merged into one PDF (in order of the checklist) and clearly entitled with your **Full Name, School, Supervisor.**

Please note that for all undergraduate research projects the supervisor is considered to be the Principal Investigator for the study.

If the proposal has been submitted for approval to an external, properly constituted ethics committee (e.g. NHS Ethics), then please submit a copy of the application and approval letter to the Secretary of the Ethics Sub-Committee. Please note that you will also be required to complete the St Mary's Application for Ethical Approval.

Before completing this form:

- Please refer to the **University's Ethical Guidelines**. As the researcher/ supervisor, you are responsible for exercising appropriate professional judgment in this review.
- Please refer to the Ethical Application System (Three Tiers) information sheet.
- Please refer to the Frequently Asked Questions and Commonly Made Mistakes sheet.
- If you are conducting research with children or young people, please ensure that you read the **Guidelines for Conducting Research with Children or Young People**, and answer the below questions with reference to the guidelines.

Please note:

In line with University Academic Regulations the signed completed Ethics Form must be included as an appendix to the final research project.

If you have any queries when completing this document, please consult your supervisor (for students) or School Ethics Sub-Committee representative (for staff).

St Mary's Ethics Application Checklist

The checklist below will help you to ensure that all the supporting documents are submitted with your ethics application form. The supporting documents are necessary for the Ethics Sub-Committee to be able to review and approve your application.

Please note, if the appropriate documents are not submitted with the application form then the application will be returned directly to the applicant and may need to be re-submitted at a later date.

	Enclosed? (delete as appropriate)		Version No
Document	Yes	Not applicable	
1. Application Form	Mandatory		
2. Risk Assessment Form	YES		
3. Participant Invitation Letter	Yes		
4. Participant Information Sheet	Mandatory		
5. Participant Consent Form	Mandatory		
6. Parental Consent Form	YES		
7. Participant Recruitment Material - e.g. copies of Posters, newspaper adverts, website, emails		Not Applicable	
8. Letter from host organisation (granting permission to conduct the study on the premises)	Yes		
9. Research instrument, e.g. validated questionnaire, survey, interview schedule		Not applicable	
10. DBS **(to be sent separately)**	YES		
11. Other Research Ethics Committee application (e.g. NHS REC form)		Not applicable	
12. Certificates of training (required if storing human tissue)		Not applicable	

I can confirm that all relevant documents are included in order of the list and in one PDF document (any DBS check to be sent separately) named in the following format: ***Full Name, School, Supervisor.***

Signature of Applicant:

Signature of Supervisor:

St Mary's University Twickenham London

Ethics Application Form

Name of proposer(s)	Thomas Fisher
St Mary's email address	145242@live.stmarys.ac.uk
Name of supervisor	Dr Daniel Cleather

Title of project Is movement quality associated with relative strength in adolescent rugby union players?

School or service	SHAS
Programme (whether undergraduate, postgraduate taught or postgraduate research)	MSc Strength and Conditioning
Type of activity/research (staff/undergraduate student/postgraduate student)	Postgraduate Dissertation

Confidentiality	
Will all information remain confidential in line with the Data Protection Act 1998?	YES

Consent	
Will written informed consent be obtained from all participants/participants' representatives?	YES

) Pre-approved protocol	
Has the protocol been approved by the Ethics Sub-Committee under a generic application?	NO

) Approval from another Ethics Committee	
Will the research require approval by an ethics committee external to St Mary's University?	NO
Are you working with persons under 18 years of age or vulnerable adults?	YES

) Identifiable risks	
Is there significant potential for physical or psychological discomfort, harm, stress or burden to participants?	NO
Are participants over 65 years of age?	NO
Do participants have limited ability to give voluntary	NO

consent? This could include cognitively impaired persons, prisoners, persons with a chronic physical or mental condition, or those who live in or are connected to an institutional environment.	
Are any invasive techniques involved? And/or the collection of body fluids or tissue?	NO
Is an extensive degree of exercise or physical exertion involved?	YES
Is there manipulation of cognitive or affective human responses which could cause stress or anxiety?	NO
Are drugs or other substances (including liquid and food additives) to be administered?	NO
Will deception of participants be used in a way which might cause distress, or might reasonably affect their willingness to participate in the research? For example, misleading participants on the purpose of the research, by giving them false information.	NO
Will highly personal, intimate or other private and confidential information be sought? For example sexual preferences.	NO
Will payment be made to participants? This can include costs for expenses or time.	NO
Could the relationship between the researcher/ supervisor and the participant be such that a participant might feel pressurized to take part?	YES
Are you working under the remit of the Human Tissue Act 2004?	NO

13) Proposed start and completion date
Please indicate: When the study is due to commence. Timetable for data collection. The expected date of completion. Please ensure that your start date is at least 3 weeks after the submission deadline for the Ethics Sub-Committee meeting.
Data collection will take place during March of 2017. Two weekly sessions will be made available so that participants can undergo the testing protocol at a convenient time. It is expected that all the data will be collected by March 31st 2017.

14)Sponsors/Collaborators
Please give names and details of sponsors or collaborators on the project. This does not include your supervisor(s) or St Mary's University. Sponsor: An individual or organization who provides financial resources or some other support for a project. Collaborator: An individual or organization who works on the project as a recognized contributor by providing advice, data or another form of support.
Collaborator: King Edward's School, Bath. The school at which I work, who will provide facilities and participants for the study.

15. Other Research Ethics Committee Approval
Please indicate whether additional approval is required or has already been obtained (e.g. the NHS Research Ethics Committee). Please also note which code of practice / professional body you have consulted for your project. Whether approval has previously been given for any element of this research by the University Ethics Sub-Committee.
N/A

16. Purpose of the study
In lay language, please provide a brief introduction to the background and rationale for your study. Be clear about the concepts / factors / performances you will measure / assess/ observe and (if applicable), the context within which this will be done. Please state if there are likely to be any direct benefits, e.g. to participants, other groups or organisations.
Parsonage et al.'s (2014) study on the relationship between movement quality and various measures of physical performance found that those who scored the highest on their Conditioning Specific Movement Task (CSMT) assessment also recorded the best times on 10m, 20m and 40m sprints, the highest vertical jump heights and the best Yo-yo intermittent recovery test scores. Despite finding no significant differences between the body mass of the participants (across groups distinguished by performance on the CMST), the best performing group had a mean body mass of 66.7 kg, whereas the mean for the whole cohort was 74.4 kg. Therefore, it could be argued that the authors did not adequately account for body mass as a variable in the performance of both the CSMT and their measures of physical performance. Considering these problems with the work of Parsonage et al. (2014), the purpose of this study is to investigate the relationship between movement quality and relative strength in talent identified adolescent rugby union players. Relative strength has been selected as a variable as it can arguably be seen to account for performance the physical tests used by Parsonage et al. (2014) and in their CSMT assessment; the study aims to suggest that relative strength has a positive correlation to movement quality in the population under study. Movement quality will be measured using some of the CSMT assessment developed by Parsonage et al. (2014). Relative strength will be measured using an isometric mid-thigh pull (IMTP) as it has been repeatedly correlated to strength across a variety of populations. IMTP scores will be taken unilaterally and bilaterally. Given that the population under study will have different levels of familiarity and experience with barbell training, it is preferable to the use of a repetition max test on traditional barbell exercises. It is also more ecologically valid then using an isokinetic dynamometer, as it does not isolate a single joint, but gives a more complete picture of the athlete's ability to produce force. The participants will be U15, U16 and U17 member of 'A' team squads representing KES Bath school. The study will be of benefit to both the athletes and their coaches as it will contribute to the ongoing battery of assessments and monitoring done by their strength and conditioning staff. The study will also progress the field of strength and conditioning by leading to a better understanding of what is meant by movement quality and the ways in which it is developed.

17. Study Design/Methodology
In lay language, please provide details of: The design of the study (qualitative/quantitative questionnaires etc.) The proposed methods of data collection (what you will do, how you will do this and the nature of tests). You should also include details regarding the requirement of the participant i.e. the extent of their commitment and the length of time they will be required to attend testing. Please include details of where the testing will take place. Please state whether the materials/procedures you are using are original, or the intellectual property of a third party. If the materials/procedures are original, please describe any pre-testing you have done or will do to ensure that they are effective.
The study will assess the correlation between quantitative scores for the CSMT assessments and relative mean force (N.kg-1) and relative peak force (N.kg-1) from the IMTP. The CSMT protocol will use the criteria outlined by Parsonage et al. (2014) to measure the quality of an overhead squat, single leg squat, counter movement jump, single leg jump landing, Romanian deadlift and sprint. A standardized demonstration of each movement pattern will be given to the participants, who will also be provided with the same standardized instructions in written form. The participants will then be allowed to perform 3 practice repetitions of each movement before performing 2 recorded repetitions. For the single leg squat, participants will perform all repetitions on the left leg before the right. All CSMT tasks (except for the sprint) will be filmed by 2 video cameras; one from the sagittal plane and one from the frontal plane (on the right-hand side of the participant's body). The sprint will only be filmed from the frontal plane, with the analysis of the movement taking place between 20-40m. The position of the video cameras and the testing site will be measured to ensure continuity throughout the process, as it is unlikely that all of the tests will be done in one sitting. Cook's FMS 4-point scale will be adopted to assess and give scores ranging from 0 to 3. A score of 3 indicates that subject can execute the movement correctly. A score of 2 indicates that the subject can correctly complete the movement, but with the presence of compensatory movements. A score of 1 indicates that they are unable to complete the movement correctly. If any pain is recorded the participants will be given 0. A participant is deemed 'competent' if they score 2 or above. Detailed criteria are available from Parsonage et al. (2014) and in the detailed version of the research proposal. To obtain the isometric mid-thigh pull data, the correct height for the bar will be assessed through a familiarization session. The participants will then warm-up with instructions to pull at 50% and 75% of their maximal effort. 7 trials of maximal IMTP will then be performed, separated by 2 minutes of rest. Of the 7 lifts, 3 will be bilateral and 4 will be unilateral (2 on each leg). The order of the lifts will be randomised for each participant to ensure that the effect of fatigue will be minimised. Subjects will be instructed to pull as hard as possible and verbal encouragement will be given during the lift. Each IMTP trial will last for 5 seconds. On arrival, the weight, standing height, sitting height and date of birth will be recorded in order to estimate their physical maturity. The CSMT assessments will begin with a standardised warm up followed by the sprint assessment taking place on the outdoor

move inside to the gym for the rest of the testing which will take place in the following order: 1) overhead squat 2) Romanian deadlift 3) single leg squat 4) countermovement jump 5) single leg landing 6) IMTP. The testing has been organised as such for three reasons i) to ensure all candidates receive a standardised warm up prior to testing to reduce injury risk ii) CSMT testing will be done before IMTP testing to ensure it is done without fatigue and iii) this procedure will be the most efficient use of space and time. It is expected that participants will be required to give no more than 90 minutes of their time. However, trial runs of the procedure will be needed to ensure that the process is as efficient as possible. It is likely that participants will be tested in groups of 5-10 to ensure that group sizes are manageable.

The testing will take place at King Edward's School in Bath. All tests except for the sprint will be done in the gymnasium. The sprint test will be done on their outdoor 4G AstroTurf pitch.

The CSMT was developed by Parsonage et al. (2014) and IMTP has been widely used in scientific literature.

18. Participants
Please mention: The number of participants you are recruiting and why. For example, because of their specific age or sex. How they will be recruited and chosen. The inclusion/exclusion criteria. For internet studies please clarify how you will verify the age of the participants. If the research is taking place in a school or organisation then please include their written agreement for the research to be undertaken.

60 male participants will be invited to take part in the study; all of whom are member of the rugby union ‘A’ teams at the U15, U16 and U17 age groups at King Edward’s School Bath. Participation maturation will be measured using the maturation offset measurement protocols. This population is being used as it closely resembles that used by Parsonage et al. (2014) whilst also being practically feasible for the researcher.
The participants will be recruited by obtaining permission from their parents.
Inclusion criteria; any student who has played 2 or more games for the ‘A’ team in their respective year group. Exclusion criteria; any student any student whose health has resulted in them being unable to participate in the KES Bath physical education and games programs will not be allowed to participate in the study. Any student who does not have parental consent will not be allowed to participate. 20 participants will be the minimum number required for the study to go ahead.

19. Consent
If you have any exclusion criteria, please ensure that your Consent Form and Participant Information Sheet clearly makes participants aware that their data may or may not be used. Are there any incentives/pressures which may make it difficult for participants to refuse to take part? If so, explain and clarify why this needs to be done Will any of the participants be from any of the following groups? Children under 18 Participants with learning disabilities Participants suffering from dementia Other vulnerable groups. If any of the above apply, does the researcher/investigator hold a current DBS certificate? A copy of the DBS must be supplied **separately from** the application. How will consent be obtained? This includes consent from all necessary persons i.e. participants and parents.
As a teacher at King Edward's School there is the possibility that I, other members of staff or even other students within the school, could pressurize individuals to participate in the study. To ensure that such pressure is minimized I will firstly limit public discussion of the study and attempt to limit personal communication with students regarding the study during normal school hours. I will also ensure that other members of staff do the same. It is hoped that by limiting the public profile of the study I will minimize the potential for students to pressurize one another into participating. Participants will be children under the age of 18. DBS form has been sent. Parental consent will need to be obtained. A letter will be sent home to all of the parents of the potential participants. The letter will invite them, and their child, to read an information sheet outlining the purpose, nature and practicalities of the study. If they feel that, having read the information, they wish to give consent for their son to participate they will be able fill out a consent form doing so. However, the letter will also invite them to a brief presentation and Q&A in mid-February, to which they and their son are invited. If, having attended the presentation and Q&A they feel ready to give their son consent to participate, there will be another opportunity to fill out a consent form. An informed agreement form will also be obtained from ever child whose parents have given their consent.

20. Risks and benefits of research/ activity
Are there any potential risks or adverse effects (e.g. injury, pain, discomfort, distress, changes to lifestyle) associated with this study? If so please provide details, including information on how these will be minimised. Please explain where the risks / effects may arise from (and why), so that it is clear why the risks / effects will be difficult to completely eliminate or minimise. Does the study involve any invasive procedures? If so, please confirm that the researchers or collaborators have appropriate training and are competent to deliver these procedures. Please note that invasive procedures also include the use of deceptive procedures in order to obtain information. Will individual/group interviews/questionnaires include anything that may be sensitive or upsetting? If so, please clarify why this information is necessary (and if applicable, any prior use of the questionnaire/interview). Please describe how you would deal with any adverse reactions participants might experience. Discuss any adverse reaction that might occur and the actions that will be taken in response by you, your supervisor or some third party (explain why a third party is being used for this purpose). Are there any benefits to the participant or for the organisation taking part in the research (e.g. gain knowledge of their fitness)?
There is a chance that some of the activities could be potentially injurious or result in acute pain if performed incorrectly or if performed by someone with a medical history predisposing them to injury through physical activity. To minimize the risk to participants, demonstrations and opportunities to practice each technique will be given prior to their performance. Any acute pain experienced by the candidates when executing a skill will result in the immediate termination of testing and appropriate administration of medical provision. The parents of the candidates will also have to sign a PAR-Q in order to ensure that the participants are healthy enough to perform the physical activity required by the tests in a safe way. See above. Furthermore, acute injury may as a result of an in appropriate warm up. Thus, a standardized warm up will be put in place to ensure participants are ready to complete each section of the test. No No Any adverse reactions will be dealt in accordance with the policies used by King Edward's School, Bath. For example, in the unlikely event of an injury, the school nurse is in an adjacent building to the gymnasium and can immediately be called to the participant. Minor injuries can be easily dealt with as medi-bags and first aid trained staff will be on hand during the testing. Yes, participants will be gain an understanding of their movement quality and relative strength. On completing the tests, the candidates will be invited to a follow up session in which they will be given a strength and conditioning program.

21. Confidentiality, privacy and data protection
What steps will be taken to ensure participants' confidentiality? Please describe how data, particularly personal information, will be stored (all electronic data must be stored on St Mary's University servers). Consider how you will identify participants who request their data be withdrawn, such that you can still maintain the confidentiality of theirs and others' data. Describe how you will manage data using a data a management plan. You should show how you plan to store the data securely and select the data that will be made publically available once the project has ended. You should also show how you will take account of the relevant legislation including that relating data protection, freedom of information and intellectual property. Who will have access to the data? Please identify all persons who will have access to the data (normally yourself and your supervisor). Will the data results include information which may identify people or places? Explain what information will be identifiable. Whether the persons or places (e.g. organisations) are aware of this. Consent forms should state what information will be identifiable and any likely outputs which will use the information e.g. dissertations, theses and any future publications/presentations.
All data and video footage will be stored on St. Mary's University servers. On arrival at the testing, participants will be assigned a number. Thus, participants who request their data to be withdrawn can be easily identified. The data which will be made publically available will not identify any of the individuals who have taken part in the study. No video footage which could identify the participants will be released. All other data relevant to the results of the study will not contain any information which could identify the participants. Thomas Fisher and Dr. Daniel Cleather No. The results of the study will not mention the name of the school, only that they were 'adolescent rugby players'.

22. Feedback to participants
Please give details of how feedback will be given to participants: As a minimum, it would normally be expected for feedback to be offered to participants in an acceptable to format, e.g. a summary of findings appropriately written. Please state whether you intend to provide feedback to any other individual(s) or organisation(s) and what form this would take.
Participants will be given an A4 feedback sheet which they will be able to collect from my classroom at King Edward's School, Bath. An electronic copy of the same document will also be made available. Participants will also be invited to a follow-up session in which they receive a strength and conditioning program appropriate to their results.

The proposer recognises their responsibility in carrying out the project in accordance with the University's Ethical Guidelines and will ensure that any person(s) assisting in the research/ teaching are also bound by these. The Ethics Sub-Committee must be notified of, and approve, any deviation from the information provided on this form.

Signature of Proposer(s)	Date: 01/12/16
Signature of Supervisor (for student research projects)	Date: 06/12/16

St Mary's University Twickenham London

Approval Sheet

Name of applicant: Thomas Fisher

Name of supervisor: Dr Daniel Cleather

Programme of study: MSc Strength and Conditioning

Title of project: Is movement quality related to relative strength in adolescent rugby players?

Supervisors, please complete section 1 or 2. If approved at level 1, please forward a copy of this Approval Sheet to the School Ethics Representative for their records.

SECTION 1

Approved at Level 1

Signature of supervisor (for student applications).....

Date.....

SECTION 2

Refer to School Ethics Representative for consideration at Level 2 or Level 3

Signature of supervisor..... .....

Date.....06/12/16.....

SECTION 3

To be completed by School Ethics Representative

Approved at Level 2

Signature of School Ethics Representative.....

Date.....

SECTION 4 To be completed by School Ethics Representative. Level 3 consideration required byt the Ethics Sub-Committee (including all staff research involving human participants) Signature of School Ethics Representative.....

St Mary's University Twickenham London

PRACTICAL ACTIVITY RISK ASSESSMENT FORM

The following Risk Assessment template may be used by any individual intending to undertake a research or practice activity. This should be completed in combination with a relevant activity approval or Ethics Application form where relevant. Referring to appropriate sources of information, including the HSE website and University Health and Safety Policy Guidelines, the relevant activity coordinator must complete the fields below to adequately address the stages of managing hazards in any working environment.

Section 1 – Activity and Coordinator details:

Activity coordinator name:	**Thomas Fisher**	**Tutor / supervisor:**	**Dr Daniel Cleather**
Phone number:	**07890390138**	**Email address:**	**145242@live.stmarys.ac.uk**
Activity title:	**MSc Student**		
Activity location(s) full details:	**KES Bath School, North Road, Bath , BA2 6HU**		

Outline of activity (please specify the type of activity being undertaken):	**No**	**Yes**	**If yes, please provide details:**
1. Use of Human Subjects: demographic type, requirements, age/young persons?		YES	Adolescent rugby players
2. Use of an intervention (either solely or in combination) including dosage or application: E.g. ingestion of food, liquids or supplement, diet, massage, occlusion, environmental exposure, physical activity or other. **Outline of specific dosage or application where relevant** E.g. mg per kilo of body weight	No		
3. Use of data and/or sample collection (solely or in combination): E.g. questionnaire/survey, human tissue sampling (blood / urine / saliva / sweat or other), respiratory analysis, body composition, performance tests or other.		Yes	Performance tests
4. Use of chemicals/gas cylinders: Type(s), hazardous or not, MSDS available?	No		
5. Equipment to be used:			
Video cameras, force plates, power rack, barbells and plates.			

SECTION 2: Risk Controls - *For each hazard identified in Section 1, complete Section 2. Please refer to the Risk Assessment Guidance notes on simmsCAPital folder for Risk Matrix.* ***Please note that L refers to Likelihood; S refers to Severity and RS refers to Risk Score (L times S equals RS)***

Outcome due to Hazard description (Substance / equipment / procedure)		**Initial Risk Level** High(13-25) Med (5-12) Low (0-4)	Necessary controls to eliminate or adequately reduce the **Initial Risk Level** of an associated hazard to a suitable **Remaining risk level**.	**Remaining Risk Level** High (13-25) Med (5-12) Low (0-4)
1	Access and usage of designated facility, site or location, including private or public.	High (12) L= 4 S=4	Written approval to access and make use of the designated facility, site or location must be sought from the relevant owner, keeper or manager, where appropriate. Terms & conditions, qualifications, notification, booking requests, reporting, statements of intent or other formal agreement must be confirmed in advance of access and use. A separate assessment of local hazards should be undertaken to ensure safe working practice. Gauge which person(s) will be responsible for dealing with any potential emergency incident, including use of First Aiders, Security or other individual.	Low (1) L=1 S=1
2	Fire management and evacuation	Med (10) L= 2 S=5	Ensure appropriate responsibilities of relevant individuals or parties are established ensuring fire prevention, evacuation and individual roles are established prior to activity commencing. Please refer to school policy.	Low (3) L=1 S=3
3	Environmental exposure (internal and external) including temperature, humidity, lighting ventilation or relative weather conditions	Low (4) L=1 S=4	Ensure suitable local working conditions including regulating temperature, lighting, and humidity where possible. Prepare relevant individuals to manage uncontrollable/unavoidable conditions including instruction on use of personal protective equipment, clothing, shelter, rehydration, rest periods/breaks or other relevant means to maintain suitable comfort and function. Brief individuals on managing experience of deliberate exposure to stressful conditions, including adequate avoidance of visual/physical exposure to sources of high level lighting and associated heat. Ensure low lighting allows participant to still work safely including avoiding injury or subsequent strain/pathology.	Low (1) L=1 S=1
4	Risks relating to layout , storage, space, obstructions including fall of objects, spillages, slips, trips & falls	Med (6) L= 2 S=3	Ensure all equipment layouts maintain a safe working environment. Ensure measures are in place to manage trip hazards including suitable form(s) of cable covers, excess cabling, objects or equipment do not affect walkway routes. Highlight visually and by instruction unavoidable trip hazards. Manage liquids to avoid spillages. Establish equipment available to manage spillages and who is responsible to address an incident. Ensure the avoidance of any falling object, or safe management processes for any item likely to or intended fall.	Low (1) L=1 S=1
9	Human subject physical activity, manipulation, treatment or other including use of equipment where relevant.	Med (12) L= 3 S= 4	Prior to commencing any activity, ensure the practical activity coordinator(s) has completed all necessary competency training as specified on Section E) of the Student Research Approval Form. Adhere to the University Ethics procedures ensuring all human subjects have received a relevant information sheet, completed an Informed consent form and (Physical Activity Readiness Questionnaire (PARQ)/Medical History Form under the relevant Health and Safety procedures. Ensure documents are countersigned and dated at the same time (witness process) by the relevant research coordinator. Ensure documents are retained during the testing period, and then returned to the University for data protected archiving when testing has been completed This may vary where members of the public are approached on an 'at the time' basis under typical survey work. All ingestion interventions must address maximum safe dosage fit for the relevant human participant (s).	Low (4) L=2 S=2

SECTION 3: Arrangement for supervision and/or monitoring effectiveness of control

Monitoring achieved through pre and post checks, continual test supervision and/or a separately recruited individual where further supervision or monitoring is required. Even where students demonstrate high levels of competency, regular checks should be made by supervising staff that should also be readily available to assist with any questions or problems students might have. Any practice should be amended or stopped if an emerging hazard dictates such a response. This option should be adopted where any uncertainty occurs, seeking advice from suitable staff.

SECTION 4: Referral guidelines relevant to the intended activity (scanned PDF of hard copy, listed web link or other source):

Please ensure that all relevant reliable sources of information can be easily referred to at any time both during the preparation phase and period of activity. Please note some of the relevant University links will include:

Information source	Location	Areas of information
Student Information Folder	MyModules	Student Research Approval Form Laboratory specific guidelines and consumable costs School of SHAS Use of Human Tissue Guideline (new)
University Ethics Committee	Student portal	Ethics Application process and associated forms Example Human Subject Consent Form
University Health and Safety portal	Student portal	Health and Safety Policy guidelines including Risk Management, Loan working, Manual lifting, Display Screen Equipment and COSHH
The Health and Safety Executive	Website found through any web search engine	Well-presented sources of legally approved regulation and legislation covering COSSH, CHIP, RIDDOR, DSE and many other areas of health and safety at work
Further discipline specific sources of information may be relevant to the area of activity including accreditation bodies such as **BASES, BASRAT, SENR, AfN, BPS, UKSCA, REPS, HTA, ITEC etc**		

SECTION 5: Emergency response procedures

In the event of an emerging incident, engage the individual(s) who have been previously agreed as responsible for addressing an emergency incident.

Assess and eliminate (where safe) hazards that might place the individual(s) needing care or carer(s) at risk. Apply up to date first aid and/or seek medical assistance where appropriate. Contact relevant staff where relevant.

Important contact details (including where activities are undertaken off campus):

- **King Edward's School Duty Porter:** 07780 687905
- **King Edward's School Reception:** 01225 464313

SECTION 7: Period of cover – ***If a more complex assessment is required, continue below:***

PERIOD OF COVER FOR TASK/EVENT		PRINT NAME OF TASK/EVENT LEADER(S)	SIGNATURE	DATE SIGNED	HAZARDS IDENTIFIED (mark with a tick or a cross)
FROM	TO				

SECTION 8: Student liability declaration:

By signing this risk assessment I confirm that I have read and understood the above information that is relevant to my activity, and will ensure adherence to appropriate practice at all times, based on completing formal competency training relevant to the activity I am planning to undertake. I understand that the above statements are intended to be generalised, being applicable to all forms of activity. Not all parts may apply to a specific activity, but it is my responsibility to outline any possible/further detail of necessary hazard management procedures as safety notes within the relevant activity methodology, as statements of intent within the associated Ethics Application Form and as associated Human Subject Consent Form and Information sheet.

SIGNATURE:		**PRINT NAME:**	**Thomas Fisher**	**DATE COMPLETED:**	04/12/

APPENDIX 2: ETHICS APPROVAL LETTER

St Mary's University Twickenham London

27 January 2017 Unique Ref: SMEC_2016-17_033

Thomas Fisher (SHAS): 'Is movement quality associated with relative strength in adolescent rugby union players?'

Dear Tom

University Ethics Sub-Committee

Thank you for submitting your ethics application for the above research.

I can confirm that your application has been considered by the Ethics Sub-Committee and that ethical approval is granted.

Yours sincerely

Prof Conor Gissane
Chair of the Ethics Sub-Committee

Cc Dr Daniel Cleather

St Mary's University Twickenham London

Dear Parent,

You're receiving this letter because your son is in the appropriate population to participate in a postgraduate research study being undertaken by a KES member of staff.

Please see the information sheet below, which outlines exactly what participation in the study will entail. There is also an information sheet for your son to read, if you'd like him to.

If, having read the sheet, you'd like to give your consent for your son's participation then please fill out the parental consent form and ask your son to drop it into my classroom (B24) at his earliest convenience.

If you still have some more questions, or would like to know some more information please feel free to contact me. I would also like to invite you to a brief presentation which will take place at 5pm on…….February in ……at King Edward's School.

I look forward to hearing from you.

Yours faithfully,

Tom Fisher

Section A: The Research Project

1. What is the title of the project?
   Is movement quality related to relative strength in adolescent rugby players?

2. What is the purpose and value of the study?
   The purpose of this study is to investigate the relationship between movement quality and relative strength in adolescent rugby union players. 'Movement quality' is a difficult term to define but in this setting, it refers to how well a movement can be executed compared to an 'ideal' technical model and it is primarily used as a way of gauging potential injury risk to athletic populations. There are several different protocols used to measure it but there is no consensus as to which is most appropriate to use with an adolescent population. Furthermore, at the time of writing very little data exists which can clarify the nature of the relationship between movement quality and markers of physical performance, especially in adolescent populations. The data which is available, primarily the work of Parsonage et al. (2014), seems to suggest that there is a correlation between movement quality and some markers of physical performance, however more research is needed to clarify the exact nature of this relationship.

   The study will have value for strength and conditioning professionals working with adolescent populations. Although further research will be needed, the study aims to confirm the value of relative strength as both a predictor of performance and of movement quality in these populations, which will have implications on the way in which they could be trained.

3. Why is my son being invited to participate?
   Your son will be invited to participate as he has played for 'A' team in his respective year group. Your son's participation in the study will be subject to your informed consent and your son's informed agreement.

4. Who is organising the research?
   The research is being organised by Tom Fisher, a teacher and coach at KES, who is currently in his final year of an MSc in Strength and Conditioning with St. Mary's University Twickenham.

5. What will happen to the results of the study?
   Although I'm aiming to produce the best work possible, it is highly unlikely that the results of the study will be seen by anyone outside of the faculty of the school of sport, health and applied science at St. Mary's University, Twickenham. In the unlikely event that they are published to a wider audience, any information which could identify the participants will have been removed.

6. Is the research being funded by anyone? No.

7. For Further information please contact:
   145242@live.stmarys.ac.uk

Section B: Your son's Participation in the Research Project

1. Why your son has been invited to take part?
   As a member of the 'A' team rugby squad in his respective year your son is a member of the population who could participate in the study

2. Can he refuse to take part?
   There is no obligation from them to take part and even if you do give your consent for their participation they are perfectly within their rights to withdraw at any point.

3. Can my son withdraw from the project? If so, how?
   To withdraw they will need to fill in the withdrawal form on the bottom of the consent form.

4. What will happen if you son takes part?
   Should your son agree to take part in the study they will be asked to attend a testing session after school in the second half of the Easter term which will take no more than 90 minutes.

   During the testing your son will be asked to perform the following 6 movements:

1. Romanian Deadlift

2. Overhead Squat

3. Single Leg Squat

4. Broad Jump into Single Leg Landing

5. Sprint

6. Counter Movement Jump

For each movement, he'll be given a score of 0-3 according to how well he performs it. Each movement will be recorded on video so that the correct score can be given. The total score for all 6 tests will be his overall score for movement quality. He'll then be asked to do this:

It's called an isometric mid-thigh pull; the bar is fixed in place and he will pull on it as hard as he can. He'll be standing on something called a force plate, which measures how much force you can put into the ground. The force plate will give us a score for his relative strength, which will then be correlated against his movement quality score.

5. Are there any risks involved? What will be done to ensure your son's safety?
As befits any activity taking place at KES, every measure will be taken to ensure your child's safety and risks will be managed as effectively as they can. The activities involved in the tests have all been used in research settings before with this population.
They are also significantly less risky than many of the sports in which your children currently participate.

6. If something does go wrong, how will it affect my legal rights?
Although it is highly unlikely that something will do wrong, your legal rights and prior agreement with KES with regard to physical activity will not be affected.

7. Must my son take any special precautions before, during or after the study?
The only special precaution will be the completion of a ParQ form prior to participation in the study.

8. What will happen to the data which is collected?
All data and videos will be stored on St. Mary's University servers and will, therefore, only be available to myself and the faculty in the school of human and social sciences.

9. Are there any benefits from taking part?
The research will be beneficial to the participants for several reasons. Firstly, it will give them some very accurate information about their own fitness. All participants will receive a copy of their results and an invitation to attend a follow-up session to get them started on an appropriate strength and conditioning program. Secondly, any students interested in studying sport science may wish to attend to get some experience of how data is collected in

the field. It will also be a very good opportunity to ask questions about what they could expect from a further education course in sport science.

10. How much time will he need to give up to take part in the project?
90 minutes, although your son will also be invited to a follow up session to get him started on a strength and conditioning program.

11. How will my son's participation in the project be kept confidential?
All information identifying your son as a participant will be removed prior to publication of the results. Also, all video information from which your son could be identified will be kept on private servers at the University of St. Mary's, Twickenham.

Mr Fisher's Research Project

Hello!

I'm currently doing an MSc in Strength and Conditioning. This means that I have to write a dissertation, the purpose of which is to try and conduct some original research.

Now, since there isn't much research on people like you and since I also happen to work with people like you, I thought studying you would be an interesting thing to do.

Here's what I'm looking at doing:

I'm going to test how well you do these 6 movements:

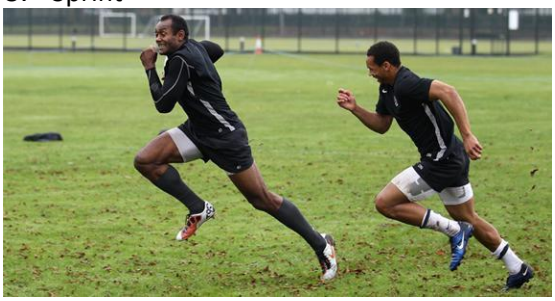
1. Romanian Deadlift

2. Overhead Squat

3. Single Leg Squat

4. Broad Jump into Single Leg Landing

5. Sprint



6. Counter Movement Jump

For each movement you'll get a score from 0-3. I'm also going to use some video equipment to record you doing each test so that I can score you accurately. These tests should give me a good indication of how well you move, your likelihood of injury and whether or not you should be lifting weights as part of a pre-season program. These tests will be videotaped in order to ensure that I can be as accurate as I can in marking you. All of the video will be safely stored and no one else will see afterwards or be able to identify you as a participant when the study is written up.

And then I'm going to test how strong you are by doing asking you do this:

It's called an isometric mid-thigh pull; the bar is fixed in place and you pull on it as hard as you can.

You'll be standing on something called a force plate, which measures how much force you can put into the ground.

You'll do unilaterally (on one leg) and bilaterally (on two legs).

Lots of research studies show that it is a good movement to predict how strong (especially in the deadlift and the squat) and fast you are.

Getting these tests done shouldn't take more than 90 minutes and we hope that they'll give you some useful information about what you could be doing to get yourself in the best possible condition for next season.

If you choose to do the testing we'll invite you to a follow up session to come and get a program to take you through to the start of the season. All of the tests are very safe but you might find isometric mid-thigh pull pretty challenging. Unfortunately, if you're carrying any injuries you won't be able to take part.

If you've got this far, thanks very much for reading.

Remember, THERE IS NO OBLIGATION TO DO THIS but if you're interested in getting some testing done then fill in the bit below and drop it into my form room (B24).

I would like to talk to Mr Fisher for his project.

Please write your name……

Please return this form to Mr Fisher as soon as possible

Mr Fisher's Research Project Consent Form

Name : _____

Please read all of the information in the red box carefully , if you're not sure about anything then ask away.

Title of the project: Is movement quality related to relative strength in adolescent rugby players?

Main investigator and contact details: Thomas Fisher 145242@live.stmarys.ac.uk

Members of the research team: Dr Daniel Cleather Daniel.cleather@stmarys.ac.uk

1. I agree to take part in the above research. I have read the Participant Information Sheet which is attached to this form.
2. I understand what my role will be in this research, and all my questions have been answered to my satisfaction.
3. I understand that I am free to withdraw from the research at any time, for any reason and without prejudice.
4. I have been informed that the confidentiality of the information I provide will be safeguarded.
5. I understand that I may be filmed for research purposes and that the footage will be kept securely and confidentially on St Mary's University servers.
6. I am free to ask any questions at any time before and during the study.
7. I have been provided with a copy of this form and the Participant Information Sheet.

Data Protection: I agree to the University processing personal data which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me.

If you're happy with everything in the box, then please fill your name, signature and the date.

Name of participant (print)……..

Signed……..…… Date…….....

St Mary's University Twickenham London

Name of Participant: _____

Title of the project: Is movement quality related to relative strength in adolescent rugby players?

Main investigator and contact details: Thomas Fisher 145242@live.stmarys.ac.uk

Members of the research team: Dr Daniel Cleather Daniel.cleather@stmarys.ac.uk

1. I agree to my child taking part in the above research. I have read the Participant Information Sheet which is attached to this form. I understand what my child's role will be in this research, and all my questions have been answered to my satisfaction.
2. I understand that I am free to withdraw my child from the research at any time, for any reason and without prejudice.
3. I have been informed that the confidentiality of the information I and my child provides will be safeguarded.
4. I understand my child may be filmed for research purposes and that the footage will be kept securely and confidentially on St Mary's University servers.
5. I am free to ask any questions at any time before and during the study.
6. I have been provided with a copy of this form and the Participant Information Sheet.

Data Protection: I agree to the University processing personal data which I and my child have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me.

Name of parent (print)……..

Signed……..…… Date…….....

CONFIDENTIAL MEDICAL HISTORY / PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q) FORM

This screening form must be used in conjunction with an agreed Consent Form.

Full Name: _____ Date of Birth: _____

Height (cm): _____ Weight (kg): _____

Have you ever suffered from any of the following medical conditions? If yes please give details:

	Yes	No	Details
Heart Disease or attack	☐	☐	_____
High or low blood pressure	☐	☐	_____
Stroke	☐	☐	_____
Cancer	☐	☐	_____
Diabetes	☐	☐	_____
Asthma	☐	☐	_____
High cholesterol	☐	☐	_____
Epilepsy	☐	☐	_____
Allergies	☐	☐	_____
Other, please give details	☐	☐	_____

Do you suffer from any blood borne diseases? If yes please give details;

Please give details of any **medication** you are currently taking or have taken regularly within the last year:

Please give details of any **musculoskeletal injuries** you have had in the **past 6 months** which have affected your capacity to exercise or caused you to take time off work or seek medical advice:

Other Important Information

During a typical week approximately how many hours would you spend exercising?

If you **smoke** please indicate how many per day:

If you drink **alcohol** please indicate how many units per week:

Are you currently taking any **supplements or medication?** Please give details:

Is there any reason not prompted above that would prevent you from participating within the relevant activity?

By signing this document I agree to inform the relevant individual(s) of any change(s) to my circumstances that would prevent me from participating in specific activities.

Signature (Participant): _____ **Date:** _____

Signature (Test Coordinator*): _____ **Date:** _____

**Test coordinator: The individual responsible for administering the test(s)/session and subsequent data collection*

St Mary's University Twickenham London
Waldegrave Road, Strawberry Hill, Twickenham TW14SX
Switchboard 020 8240 4000 Fax 020 8240 4255

KING EDWARD'S SCHOOL BATH

Ref: MJB/LW/XHPc

M T Fisher Flat 4

8 Bathwick Street Bathwick

Bath
BA2 6NX

5 December 2016

Dear Tom,

Further to your recent request, I am writing to confirm that I give my permission for you to use the facilities at King Edward's School and to include KES pupils (Year 11 and Sixth Form) in your MSc dissertation research. I understand that pupil involvement will be on a voluntary basis and look forward to receiving more details of the programme in due course.

Yours sincerely,

Mark Boden

Martin J Boden HEADMASTER