The effects of wide vs. self-selected squat stance width on performance indices in elite rugby league players; an 8-week pre-season randomized control intervention.

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Abstract

This study examined the efficacy of wide compared to self-selected stance width squats in terms of mediating performance improvements during an 8-week period of pre-season training in elite rugby league players. Participants (N=26) were randomly separated into either wide (N=13) (i.e. self-selected squat stance width increased by 20%) or self-selected (N=13) squat stance width training groups, and they completed an 8-week pre-season training block. Measures of 505-agility test time (primary outcome), 3 repetition maximum (3RM) squat strength in participants self-selected stance position and counter movement jump height were measured at baseline and 8-weeks. There were no significant differences between training groups in terms of the improvements made during the intervention period for 505-agility test (wide: pre = 2.47±0.08 & post = 2.34±0.11's and self-selected: pre = 2.46±0.05 & post = 2.35±0.08's), counter movement jump (wide: pre = 42.68±9.57 & post = 44.65±9.04cm, and self-selected: pre = 49.33±6.70 & post = 50.33±4.67cm) or 3RM squat strength (wide: pre = 159.00±15.24 & post = 178.00±19.32kg and self-selected: pre = 168.33±11.73 & post =

185.56±16.48kg). As such the findings from the current randomized controlled trial suggest that there is not sufficient evidence to suggest that wide stance width squats represent a more efficacious method of resistance training prescription in elite rugby league.

Résumé

Cette étude a examiné l'efficacité des squats larges par rapport aux squats de largeur de position auto-sélectionnés en termes d'amélioration des performances pendant une période de 8 semaines d'entraînement de pré-saison chez les joueurs d'élite de la ligue de rugby. Les participants (N = 26) ont été répartis au hasard en groupes d'entraînement larges (N = 13) (c'est-à-dire que la largeur de la position de squat auto-sélectionnée a augmenté de 20 %) ou en groupes d'entraînement à la largeur de la position de squat auto-sélectionnés (N = 13), et ils ont complété un 8 Bloc d'entraînement de pré-saison d'une semaine. Mesures de la durée du test d'agilité 505 (résultat principal), de la force de squat à 3 répétitions maximales (3RM) dans la position de position auto-sélectionnée par les participants et de la hauteur de saut en contre-mouvement ont été mesurées au départ et à 8 semaines. Il n'y avait pas de différences significatives entre les groupes d'entraînement en termes d'améliorations apportées au cours de la période d'intervention pour le test d'agilité 505 (large : pré = 2.47 ± 0.08 et post = 2.34 ± 0.11 et auto-sélectionné : pré = 2.46 ± 0.05 et post = 2.35 ± 0.08), saut à contre-mouvement (large : pré = 42.68 ± 9.57 & post = 44.65 ± 9.04 cm, et auto-sélectionné : pré = 49.33 ± 6.70 & post = 50.33 ± 4.67 cm) ou force de squat 3RM (large : pré = 159.00 ± 15.24 & post = 178.00 ± 19.32 kg et auto-sélectionné : pré = 168.33 ± 11.73 & post = 185.56 ± 16.48 kg). En tant que tels, les résultats de l'essai contrôlé randomisé actuel suggèrent qu'il n'y a pas suffisamment de preuves pour suggérer que les squats à large largeur de position représentent une méthode plus efficace de prescription d'entraînement en résistance dans la ligue de rugby d'élite.

Introduction

Rugby league football is an athletic discipline representative of an intermittent contact team-based sport, typified by bouts of maximum velocity running (both with and in the absence of possession of the ball), rapid changes of direction, physical collisions, and tackling, with interceding periods of diminished activity (Naughton et al., 2020). Owing to the unique nature of the sport, rugby league therefore necessitates aptitude across several components of sporting/ athletic and anthropometric competence, including increased muscle mass, low body fat, high aerobic and anaerobic fitness as well as high muscular strength, power, speed and agility (Gabbett, King & Jenkins, 2008). Importantly, previous analyses have shown that these specific anthropometric/ physiological components of athletic capability are able to differentiate between players of different playing abilities (Baker & Newton, 2008; Speranza, Gabbett, Johnston, & Sheppard, 2015), clearly highlighting the importance of augmenting muscle mass, aerobic fitness, anaerobic fitness, muscular strength, muscular power, speed and agility as well as reducing body fat.

Owing to the significance of the aforementioned areas of physical competence in rugby league, players engage in a diverse range of training modalities to maximize improvements on these areas, and resistance training forms a significant component of rugby league training programmes (Sinclair, Edmundson & Bentley, 2022a). Rugby league athletes are engaged regularly in game activity during the season itself and have only very limited time to prepare physically for the demands of the sport between games (Sinclair et al., 2022a). As such the pre-season period, representative of a short period of high volume and high intensity training that takes place prior to the commencement of the season, affording strength & conditioning and coaching practitioners a short window to meaningly develop important aspects of physical conditioning (Comfort, Haigh, & Matthews, 2012). Once the season initiates, resistance training activities in particular are dramatically reduced (Sinclair et al., 2022a); therefore, it is essential that resistance training programming during pre-season is as effective as possible in order to maximize performance during the season.

The barbell back squat is a cornerstone of resistance training programmes, and one of the most frequently utilized exercises for the enhancement of lower body strength and power (Schoenfeld, 2010). As a multi-joint closed kinetic chain resistance exercise, the back squat is able to mediate improvements in strength and hypertrophy of the quadriceps, hamstrings, gluteus, tibialis anterior, gastrocnemius, soleus and lumbar musculature (Myer et al., 2014). From a rugby standpoint, squat training in both unilateral and bilateral forms has been shown to produce significant improvements in important components of athletic capability in rugby players i.e. strength, sprinting and agility (Speirs, Finn & Turner, 2016). Furthermore, in rugby league players, Comfort et al., (2012) found that changes in maximal squat strength during preseason training were reflected in significantly faster 5, 10 and 20m sprints. Leading to their conclusion that to enhance short duration sprint performance, increasing maximal strength via the back squat is an important training consideration.

There are several variants to the squat e.g., front squat, back squat and box squat and a variety of technique manipulations e.g., stance width, squat depth and toe-out angles that can be made to mediate different mechanical outcomes such as muscle forces, muscle activation and joint kinematics to influence training stimuli (Slater & Hart, 2017).

Stance width has received considerable anecdotal but relatively limited research attention, although acute observational investigations in this area, suggest that it is becoming a more protuberant area of interest in strength & conditioning literature. McCaw & Melrose, (1999), Escamilla, Fleisig, Lowry, Barrentine, & Andrews, (2001) and Paoli, Marcolin, &

Petrone, (2009) showed that activation of the gluteus maximus, adductor longus, hamstring and gastrocnemius musculature were significantly enhanced with a wide stance. Escamilla et al., (2001) and Lahti, Hegyi, Vigotsky, & Ahtiainen, (2019) showed that the hip was significantly more flexed, the thigh was more horizontal, and the knee flexion angle was significantly reduced in the wide condition. In addition, their analysis of joint torques showed that the knee extensor moment, ankle plantarflexor moment and the hip to knee joint extension moment ratio were significantly larger in the wide conditions. Finally, Sinclair et al., (2022b) showed that a narrow stance increased peak vertical ground reaction force (GRF) and quadriceps forces, whilst a wide stance significantly increased medially directed GRFs as well as gluteus maximus, hamstring, gastrocnemius and soleus forces. These observations led to their conclusion that owing to increased medial GRF's and targeting of the lower extremity posterior chain musculature, that greater stance widths may improve sprint and rapid change of direction performance in addition to lower body power development.

Rationale

Despite acute observational investigations indicating that manipulating the stance width can mediate distinct mechanical outcomes during the squat, there has yet to be a randomized intervention exploring the effects of stance width manipulation on performance indices. Therefore, a randomized controlled investigation concerning the influence on pertinent performance indices in rugby league may be of considerable practical relevance to both strength & conditioning coaches and rugby league athletes.

Aim

The aim of the current study was to investigate the effects of increasing squat stance width compared to self-selected stance width using a randomized controlled investigation. This trial will compare the effects of the aforementioned stance widths in mediating improvements in speed, strength, agility and countermovement jump performance during an 8-weeks period of pre-season training in elite rugby league players. The primary outcome of this randomized intervention trial will be the 505-agility test and secondary indices will be squat strength, anthropometrics and counter movement jump height. The 505-agility test examines several physical indices including change-of-direction, speed and agility that are pertinent to rugby league (Gabbett, King & Jenkins, 2008), and was selected as primary outcome on this basis.

Hypotheses

In relation to the primary outcome, it is expected that the wide stance group will mediate improvements to a significantly greater extent than those in the self-selected stance width group. Furthermore, for the secondary outcomes, it is hypothesized that the narrow stance width group will produce improvements in counter movement jump height to a greater extent than those shown in the wide stance group, but no differences in squat strength will be observed.

Methodology

Study design and setting

This investigation represents an 8-week parallel randomized controlled intervention (Figure 2). Participants were randomized by a computer program (Random Allocation Software) to either the self-selected stance or wide stance groups, stratified to include similar number of forwards and backs in each group (taking into account the odd number of participants required in each group). This investigation was undertaken at the training ground (based in Orrell within the county of Greater Manchester in the United Kingdom), of a professional rugby-league club playing in the Super League. The 8-week intervention period and experimental approach/ measurements were adopted in accordance with (Sinclair et al., 2021), as the duration over which the main block of the pre-season training period is conducted. The protocol was designed according to the updated guidelines for reporting parallel group randomized intervention trials

(Moher et al., 2012). The study was registered prospectively (***NCT05505786***) and approved by an institutional ethical review board (HEALTH 0231).

Inclusion criteria:

- 18 years of age and above
- Professional rugby league player at Super League level
- Minimum of 5-years of experience in the back squat
- Injury free for a minimum of 6-months at baseline
- Free from any illness at baseline

Exclusion criteria:

- 35 years of age and above
- Any injury at baseline
- Any illness at baseline
- Any international matches played during the between season break

Sample size

As a measure of both speed, agility and reactive change of direction ability pertinent to rugby league performance (Sinclair et al., 2021), it was determined that the 505-agility test score was the most appropriate measure to serve as the primary outcome variable. An a priori sample size calculation for independent group comparisons was undertaken using the formulae outlined by Rosner, (2015). Currently a minimum important difference (MID) for this parameter does not exist within the scientific literature, therefore using data from our previous work (Sinclair et al., 2021), in accordance with Sinclair, Brooks, & Butters, (2019), the MID was calculated using a distribution-based approach to detect a difference of 0.04 seconds between groups. It was determined that in order to achieve $\alpha = 5\%$ and $\beta = 0.80$, a total of 26 participants would be required, taking into account a likely drop-out rate of 10%.

Participants

Twenty-six male professional rugby league players contracted to a super-league club in the United Kingdom, volunteered to take part in this experiment. All participants were first team professional players from a Super League squad and had at least 5-years of resistance training experience. All participants provided informed consent in written form and completed a Par-Q screening form before taking part in compliance with principles outlined in the declaration of Helsinki and the Oviedo Convention.

Intervention

Both training intervention groups were incorporated into the players traditional pre-season programme. The interventions were scheduled over an 8-week period, during this window the participants normal training programme continued (involving 3 x 45 minutes gym and 4 x 70 minutes technical sessions per week – Table 1).The gym-based training sessions started at 1.00 pm on each scheduled day and are described in Table 2. The technical sessions started at 3.30 pm on each scheduled day except Saturday when they commended at 11am. Resistance exercise repetitions and sets, undertaken during the gym-based sessions were prescribed as a percentage of 1-repetition maximum (1RM). Owing to safety concerns and the fatiguing nature of true 1RM testing, the players 1RM was calculated every 4-weeks, using a 3-repetition max (3RM) test and validated prediction formulae (Brzycki, 1993; DiStasio, 2014).

Within the technical sessions players undertook their preparation for the on-field aspects of rugby-league. In the first 4-weeks of the 8-week pre-season period, each technical session commenced with a warm-up alongside ball handling and rugby league skills-based drills, this was followed by general fitness and conditioning drills, before concluding with a cool down and static stretching. The general fitness drills were implemented in an ad-hoc manner by the strength & conditioning coach in order to maintain an element of spontaneity into players training, but included either pyramid runs (players start on the try line, run maximally to the 20m line and back, to halfway line and back, to opposite 20m and back and to the opposite try line and back, in sets of 4 with 2 minutes rest), pitch-based corner-corner runs (players start in one corner then sprint a diagonally to the opposing corner at 70% of maximum, then jog at 40% of maximum along the touchline until they reach the parallel corner following this they repeat the aforementioned process until they return the start position, this is undertaken in sets of 5 with 2 minutes rest) and snake runs (players start on one corner of the pitch and sprint horizontally at 90% of maximum, then rest for 15 seconds whilst walking to a the try-line, this process is then repeated at the 20m, 40m, half-way line, opposing 40m, opposing 20m, opposing try-line and opposing dead ball line points, this is undertaken in sets of 5 with 2 minutes rest). In the second 4-weeks the technical sessions kept the same format only with specific fitness and conditioning drills replacing the general fitness and conditioning drills.

The specific fitness drills were again implemented in an ad-hoc manner in sets of 5 in rounds of 5 players, but included triangle drive and runs (players start at corner 1 and sprint to corner 2 during which they drive into an individual holding a contact shield, on reaching corner 2 they sprinted immediately to corner 3 and then sprinted to back to corner 1 again driving into a contact shield), zig zag, sprint and drives (players start with a 25m sprint, then turn around immediately and perform 5x5m contact shield drives, then turn and perform a second 25m sprint before finishing with a 25m sprint sidestepping through cones at 5m intervals) and step, switch, swerves (players started by undertaking a ladder foot stepping drill, following which they received a ball passed by the coach which they then immediately passed back, they then sprinted whilst sidestepping through 8 cones after which they performed 4x5m contact shield drives). As the players are habitually tested prior to and at the end of this block of pre-season training, the players pre-season training regimen was un-interrupted with the exception of the introduction of the wide-stance width to the players allocated to this group.

All experimental variables were assessed at baseline (pre) and after the intervention (post). In the self-selected intervention group, the players undertook their preseason training in an uninterrupted manner. Whereas in the wide-stance group the players undertook the squat component of their resistance training whilst increasing their habitual stance width by 20%. Importantly, from the standpoint of this randomized controlled trial; with the exception of the squat width modification, both groups undertook an identical pre-season training regimen. The increase in stance width was determined during pilot testing as being the largest comfortable increase that could be maintained safely and effectively over the course of the pre-season training period. Participants in both groups had their habitual stance width (cm) measured at baseline as the linear distance between their feet during the back squat. In the wide-stance group, a 20% increase in this distance was calculated, and participants had this distance demonstrated to them and were asked to maintain this during the intervention and were overseen by an NSCA and UKSCA accredited strength & conditioning coach throughout their resistance training sessions. The strength & conditioning coach ensured that the necessary squat distance was maintained throughout in the wide stance width group.

Table 1: Weekly pre-season training details for the players.

<table>
<tr><th></th><th>Monday</th><th>Tuesday</th><th>Wednesday</th><th>Thursday</th><th>Friday</th><th>Saturday</th><th>Sunday</th></tr>
<tr><td>Am</td><td></td><td></td><td rowspan="2">Off</td><td></td><td rowspan="2">Off</td><td>Technical session</td><td rowspan="2">Off</td></tr>
<tr><td>Pm</td><td>Gym session 1 + Technical session</td><td>Gym session 2 + Technical session</td><td>Gym session 3 + Technical session</td><td></td></tr>
</table>

Procedure

The participants pre-season training programmes were broken up into 2 x repeated 4-week blocks. The self-selected or wide-stance squat training protocols were undertaken twice per week throughout the 8-week intervention on Tuesdays (i.e. Gym session 2) and Thursdays (i.e. Gym session 2) within the scheduled gym sessions (Table 1-2).

Testing procedures

Identical testing protocols were implemented at baseline and following the 8-week intervention. Participants completed a battery of testing to provide quantitative information required to examine the efficacy of both training groups. All tests were carried out within a single testing session in a randomized order, participants were given 2 minutes recovery within tests and 4 minutes between different tests (Sinclair et al., 2021; Sinclair et al., 2022a). All testing was conducted on a Monday and commenced following a period of 24 hours rest as players do not train on Sunday (Table 1). Participants were instructed not to consume any alcohol during this period and continue with their typical training day diet. All participants completed a familiarization session on their first day back from pre-season which was a Friday, where players returned to the club for the first time prior to the commencement of formal pre-season training on the Monday. During this time all testing protocols were practiced until participants were confident.

Anthropometrics

Body mass and stature were quantified using portable digital weighing scales (Seca 875, Hamburg, Germany) and a portable stadiometer (Seca 213, Hamburg, Germany) on a level concrete surface. Skinfold thicknesses were also measured by a single Level 2 International Society for the Advancement of Kinanthropometry (ISAK) accredited practitioner. Skinfold thicknesses were examined using calibrated callipers (Harpenden, Baty International, UK) at eight sites according to the ISAK restricted profile (triceps, subscapular, biceps, iliac crest, supraspinal, abdominal, mid-thigh, and medial calf) (Esparza-Ros, Vaquero-Cristóbal &

Marfell-Jones, 2019). In line with the ISAK recommendations two measurements were taken at each site and the sum of thicknesses across the eight sites (mm) was extracted.

Strength testing

The players' 3RM, for the squat exercise was carried out in a self-selected position, on the same day for both groups during a single gym session. The 3RM values were then used as indices of strength this exercises at baseline and post-intervention (Sinclair et al., 2022b).

Counter movement jump

The counter movement jump was overseen by the aforementioned strength & conditioning coach and began with participants standing tall with hands on their hips. They were instructed to perform a counter movement by simultaneously flexing the hips and knees to a self-selected depth then explosively jumping as high as possible. Participants were instructed to land in the same position on the mat with a toe first contact. The jumps were performed on an electronic jump mat (Fusion Sports, SmartSpeed, Australia) which utilized flight time to calculate jump height (cm). All participants performed 3 jumps with 2 minutes rest in between, and the largest jump was recorded and utilized in for data analysis. In accordance with the formulae of Mahar et al., (2022), gross peak power (W) and peak normalized power (W/kg) generated during the jump was calculated.

Table 2: Gym training program information.

Gym Session 1	**Week 1 - 65% 1RM**		**Week 2 - 80% 1RM**		**Week 3 - 90% 1RM**		**Week 4 - 95% 1RM**	
Exercise	**Sets**	**Reps**	**Sets**	**Reps**	**Sets**	**Reps**	**Sets**	**Reps**
Deadlift	4	10	4	5	3	3	2	3
Bench Press	4	10	4	5	3	3	2	3
Split Squats	3	8	3	6	3	4	2	6
Lateral Lunges	3	8	3	6	3	4	2	6
Bench Rows	3	10	3	8	3	6	2	8
Strict Press	3	10	3	8	3	6	2	8
Gym Session 2	**Week 1 - 65%**		**Week 2 - 80%**		**Week 3 - 90%**		**Week 4 - 95%**	
Exercise	**Sets**	**Reps**	**Sets**	**Reps**	**Sets**	**Reps**	**Sets**	**Reps**
Pull Ups	4	10	4	5	3	3	2	3
Barbell Bridges	3	10	3	8	3	6	2	8

Back Squats	3	10	3	8	3	6	2	8
Romanian deadlifts	3	10	3	8	3	6	2	8
Strict Press	3	10	3	8	3	6	2	8
Bench Rows	3	10	3	8	3	6	2	8
<u>Gym Session 3</u>	**Week 1 - 65%**		**Week 2 - 80%**		**Week 3 - 90%**		**Week 4 - 95%**	
<u>Exercise</u>	**Sets**	**Reps**	**Sets**	**Reps**	**Sets**	**Reps**	**Sets**	**Reps**
Deadlift	4	10	4	5	3	3	2	3
Bench Press	4	10	4	5	3	3	2	3
Pull Ups	4	10	4	5	3	3	2	3
Back Squats	3	8	3	6	3	4	2	6
Lateral Lunges	3	8	3	6	3	4	2	6

<u>505-agility test</u>

Participants were assessed using a single timing gate (Fusion Sports, SmartSpeed, Australia). During the 505-agility test (Figure 1) the participants started 10 m from the timing gate (15 m from the turning line – point A) and they sprinted through the timing gate (point B) before turning on the following line (point C) and accelerating back through the timing gate. Participants were instructed to place one foot over the line as they performed the 180-degree turn. The time was recorded from when participants first ran through the timing gate and stopped when they return through the same timing gate. Each participant performed 2 trials turning on each leg (4 total) and aggregate of the fastest trial for each leg was used during data analysis.

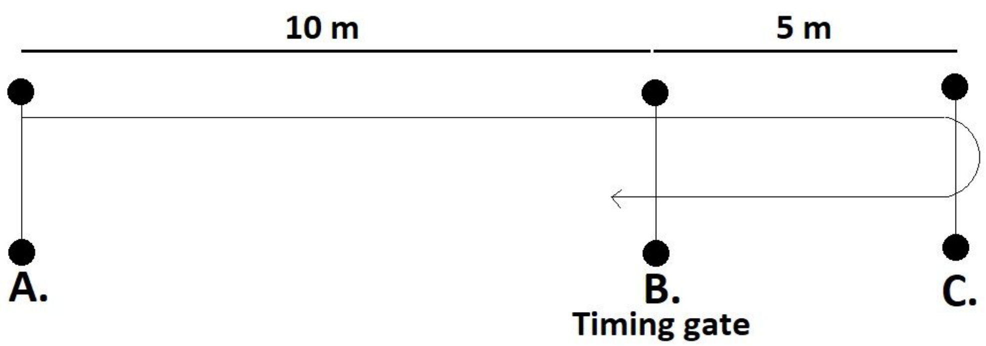

Figure 1: Diagram of 505-agility test protocol.

Statistical analyses

All experimental variables are presented as mean and standard deviations for each group. Comparisons between participant characteristics and experimental measurements (age, stature, sum of skinfolds, body mass, body mass index (BMI) and self-selected stance width) between groups were undertaken at baseline, using between groups linear mixed effects models, with group modelled as a fixed factor and random intercepts by participants (Sinclair et al., 2021). In order to examine whether there was an effect of time on all of the performance outcome measures, i.e., whether there were differences between the two experimental time points across both groups, mediated by the 8-week intervention, repeated measures linear mixed effects models were used with time (i.e., baseline and 8-weeks) modelled as a fixed factor and random intercepts by participants (Sinclair et al., 2021). Importantly, to determine the differences between the two groups in terms of their ability to mediate improvements on all of the performance outcome measures, linear mixed effects models with group modelled as a fixed factor and random intercepts by participants were adopted, adjusted for baseline values modelled as a continuous fixed covariate (Sinclair et al., 2021). We undertook the aforementioned analyses on an intention-to-treat basis and adopted the restricted maximum-likelihood method. For linear mixed models, the mean difference (*b*), t-value and 95% confidence intervals of the difference are presented. Effect sizes were calculated, using Cohen's d (*d*), in accordance with McGough, & Faraone, (2009). Cohen's d values were interpreted as 0.2=small, 0.5=medium, and 0.8=large (Cohen, 1988).

Pearson chi-square tests of independence were also used to undertake bivariate cross-tabulation comparisons between the two trial groups, specifically to test differences in the number of participants who were lost to follow-up and the number of adverse outcomes in each group (Sinclair et al., 2022c). Probability values for all chi-square analyses in this trial were calculated using Monte-Carlo simulation. All analyses were conducted using SPSS v27 (IBM, SPSS, New York, NY, USA), and statistical significance accepted at the $P \leq 0.05$ level.

Results

Baseline characteristics

There were no significant differences between groups at baseline for age (b = 0.20, (95% CI = −3.89–3.36), t = 0.27, P=0.96, d = 0.02), body mass (b = 0.77, (95% CI = −8.89–9.36), t = 0.86, P=0.86, d = 0.08), stature (b = 0.80, (95% CI = −4.21–5.10), t = 0.39, P=0.90, d = 0.06), BMI (b = 0.02, (95% CI = −2.10–2.99), t = 0.67, P=0.89, d = 0.08), sum of skinfolds (b = 4.63, (95% CI = −22.70–13.43), t = 0.54, P=0.60, d = 0.25) or self-selected stance width (b = 1.42, (95% CI = −5.67–2.82), t = 0.69, P=0.50, d = 0.29) (Table 3).

Table 3: Participant baseline characteristics (mean ± SD) from each group.

	Self-selected		**Wide**	
N (completed)	12		12	
	Mean	*SD*	Mean	*SD*
Age (y)	26.90	4.75	27.10	3.07
Stature (cm)	186.00	6.39	185.20	6.34
Sum of skinfolds (mm)	81.62	22.19	76.99	14.78
Body mass (kg)	96.56	8.66	95.79	10.03
BMI (kg/m^2)	27.91	3.11	27.93	3.69
Self-selected stance width (cm)	63.27	4.90	61.85	5.57
Forwards/ Backs	6/ 6		5/7	

Loss to follow up & adverse events

Total trial completion numbers in each group were self-selected stance (n=12) and wide stance (n=12) and number of adverse effects were self-selected stance (n=1/ back) and wide stance (n=1/ forward). The chi-squared tests were non-significant ($X^2_{(1)}$ = 0.00, P=1.00 & $X^2_{(1)}$ = 0.00, P=1.00) indicating that there were no statistically significant differences between groups in either loss to follow up or adverse events (Figure 2).

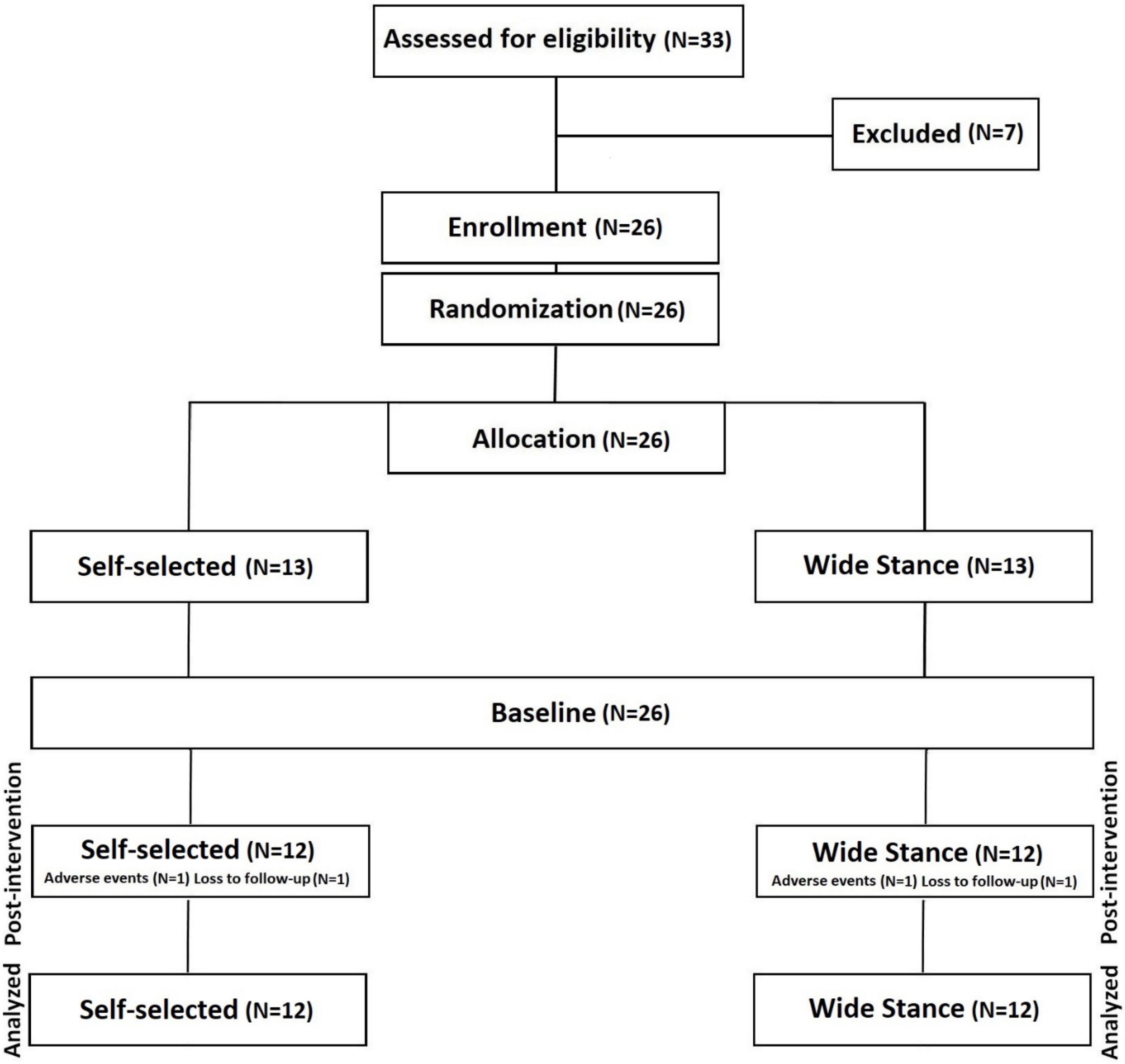

Figure 2: Consort diagram showing of participant flow throughout the study.

Anthropometrics

For body mass there were no significant effects of time in either the self-selected (*b* = 0.34, (95% CI = −0.12–0.81), t = 1.71, P=0.13, *d* = 0.57) or wide (*b* = 0.72, (95% CI = −0.23–1.67), t = 1.72, P=0.12, *d* = 0.54) groups (Table 4). There were also no significant differences between the self-selected and wide groups (*b* = 1.06, (95% CI = -0.009–2.12), t = 2.08, P=0.054, *d* = 0.97) in terms of their ability to mediate improvements in body mass (Table 4).

There were significant effects of time showing improvements in sum of skinfolds in both self-selected (b = 8.64, (95% CI = 3.53–13.76), t = 3.90, P=0.005, d = 1.30) or wide (b = 10.67, (95% CI = 6.58–14.76), t = 5.90, P<0.001, d = 1.87) groups (Table 4). However, there were no significant differences between the self-selected and wide groups (b = 3.28, (95% CI = -0.29–6.86), t = 1.95, P=0.069, d = 0.33) in terms of their ability to mediate improvements in sum of skinfolds (Table 4).

Strength testing

There were no significant differences between groups at baseline (b = 9.33, (95% CI = -3.94–22.61), t = 1.48, P=0.156, d = 0.68) (Table 4). There were significant effects of time showing improvements in 3RM squat strength in both self-selected (b = 17.22, (95% CI = 8.82–25.62), t = 3.23, P=0.001, d = 1.58) or wide (b = 19.00, (95% CI = 5.75–32.26), t = 4.94, P<0.001, d = 1.03) groups (Table 4). However, there were no significant differences between the self-selected and wide groups (b = 0.71, (95% CI = -15.28–16.70), t = 0.10, P=0.93, d = 0.12) in terms of their ability to mediate improvements in 3RM squat strength (Table 4).

Counter movement jump

For both gross (b = 172.24, (95% CI = -370.09–714.58), t = 0.69, P=0.505, d = 0.36) and normalized (b = 2.64, (95% CI = 0.61–5.89), t = 1.76, P=0.103, d = 0.86) peak power during the countermovement jump, there were no significant differences between groups at baseline (Table 4). There were no significant effects of time in the self-selected group for gross (b = 44.23, (95% CI = −150.06–238.5), t = 0.73, P=0.521, d = 0.36) and normalized peak power (b = 0.45, (95% CI = −1.74–2.64), t = 0.65, P=0.561, d = 0.33). There were also no significant effects of time in the wide group for gross (b = 45.86, (95% CI = −102.72–194.43), t = 0.73, P=0.489, d = 0.26) and normalized peak power (b = 1.98, (95% CI = −5.57–7.82), t = 1.32, P=0.26, d = 0.43) (Table 4). There were also no significant differences between the self-selected and wide groups in terms of their ability to mediate improvements in either gross (*b* = 14.84, (95% CI = -197.68–227.35), t = 0.16, P=0.878, *d* = 0.01) or normalized (*b* = 0.72, (95% CI = -2.05–3.49), t = 0.59, P=0.570, *d* = 0.22) power during the counter movement jump performance (Table 4).

For counter movement jump height, there were no significant differences between groups at baseline (*b* = 7.37, (95% CI = -1.51–16.25), t = 1.79, P=0.096, *d* = 0.87) (Table 4). There were no significant effects of time for counter movement jump in either the self-selected (*b* = 1.00, (95% CI = −6.37–4.37), t = 0.59, P=0.60, *d* = 0.30) or wide (*b* = 1.98, (95% CI = −5.57–7.82), t = 1.32, P=0.26), *d* = 0.44) groups (Table 4). There were also no significant differences between the self-selected and wide groups (*b* = 1.51, (95% CI = -8.04–5.01), t = 0.52, P=0.61, *d* = 0.23) in terms of their ability to mediate improvements in counter movement jump performance (Table 4).

<u>505-agility test</u>

There were no significant differences between groups at baseline (*b* = 0.015, (95% CI = -0.07–0.10), t = 0.37, P=0.72, *d* = 0.18) (Table 4). There were significant effects of time showing improvements in 505-agility performance in both self-selected (*b* = 0.10, (95% CI = 0.04–0.17), t = 4.25, P=0.013, *d* = 2.62) and wide (*b* = 0.13, (95% CI = 0.06–0.21), t = 4.10, P=0.005, *d* = 1.45) groups (Table 4). However, there were no significant differences between the self-selected and wide groups (*b* = 0.03, (95% CI = 0.09–0.14), t = 0.51, P=0.62, *d* = 0.34) in terms of their ability to mediate improvements in 505-agility performance (Table 4).

Table 4: Outcomes (Mean ± SD) from as a function of each training group.

	Self-selected				**Wide**				
	Pre		**Post**		**Pre**		**Post**		
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	
Sum of skinfolds (mm)	81.62	22.19	72.98	16.58	76.99	14.78	68.22	18.97	***A, B***
Body mass (kg)	96.56	8.66	96.90	8.41	95.79	10.03	95.88	8.41	
3RM Squat (kg)	168.33	11.73	185.56	16.48	159.00	15.24	178.00	19.32	***A, B***
505 agility (s)	2.46	0.05	2.35	0.08	2.47	0.08	2.34	0.11	***A, B***
Counter movement jump (cm)	49.33	6.70	50.33	4.67	42.68	9.57	44.65	9.04	

Counter movement jump peak power (W)	4580.57	677.18	4624.82	570.27	4461.24	479.06	4507.10	455.15	
Countermovement jump peak normalized power (W/kg)	48.08	2.50	48.52	1.83	45.67	3.49	46.53	4.70	

A = main effect of time in the self-selected group
B = main effect of time in the wide group

Discussion

The current investigation aimed to examine using a randomized controlled investigation, the effects of increasing the squat stance width in terms of mediating improvements in speed, strength, agility and counter movement jump performance during an 8-week period of pre-season training in elite rugby league players. This represents the first investigation in this population to examine the potential benefits of increased stance width squats using a randomized trial and may thus provide important information to strength & conditioning coaches working in elite rugby league regarding the most effective approach for the prescription of resistance training.

In relation to the primary outcome, in line with previous observations (Sinclair et al., 2021), the findings concerning the 505-agility test showed across both groups that there were significant improvements detected as a function of the eight-week pre-season intervention. However, in opposition to our hypothesis, it was also importantly revealed that there were no significant differences between training groups in terms of the improvements made during the intervention period. The increased medial GRF's shown with increased stance widths (Sinclair et al., 2022b), allied to previous suggestions that greater medial GRF's during the squat may improve preparedness for rapid change of direction tasks (Lahti et al., 2019), led to the speculation that improvements in the primary outcome would be significantly enhanced in the wide-stance group. However, the findings from this investigation do not support these proposals during the pre-season period. Speed, agility and reactive change of direction ability have been shown to be important performance-based outcomes in rugby league (Baker &

Newton, 2008; Spenanza et al., 2015). It is unfortunately not within the scope of the experimental measurements obtained within this trial to elucidate the mechanisms responsible for the lack of difference in improvements throughout the 8-week pre-season period between groups. However, it is likely that the increased squat stance width simply did not mediate a sufficiently increased or distinct training stimulus compared to that in the self-selected group. This indicates that in relation to the primary outcome there does not appear to be any evidence to suggest that the wide stance represents a more effective method of resistance training prescription in elite rugby players.

Importantly, in relation to the counter movement jump, in opposition to previous analyses exploring pre-season training in elite rugby league (Comfort et al., 2012), there were no significant improvements in either training group. Furthermore, in opposition to our hypotheses in relation to secondary outcomes, it is noteworthy that there were no significant differences between training groups in terms of the improvements in counter movement jump performance during the intervention period. Previous analyses have shown that a narrow stance increased peak vertical GRF production compared to a wide stance (Sinclair et al., (2022b), suggesting that the wide stance group may have lacked the training stimulus necessary to mediate improvements in counter movement jump performance compared to the self-selected condition. However, intervention studies have also shown the importance of the hamstring and gluteal muscle groups (both of which exhibit increased muscles forces and activation with a wide stance width - McCaw & Melrose, 1999; Escamilla et al., 2001 and Paoli, Marcolin, & Petrone, 2009 and Sinclair et al., 2022b) to jump performance owing to a greater ability to promote lateral pelvic stabilization, thus allowing these muscles to direct their power more effectively and increase the effective impulse produced during the take-off phase (Gallego-Izquierdo et al., 2020, Clark, Bryant, Culgan, & Hartley, 2005). Therefore, it could be conjectured that the distinct stimuli mediated as a function of both training conditions was such that there were no differences in the improvements arbitrated by each group in this trial. Nonetheless, it appears in relation to the counter movement jump, our findings show that neither of the stance width conditions examined in this trial appear to be anymore efficacious than the other for the prescription of resistance training aimed at improving countermovement jump performance.

In agreement with previous investigations (Sinclair et al., 2022a), both training intervention groups experienced significant improvements in squat strength during the pre-season training period. Whilst this observation was to be expected given the prominence of resistance training during this period (Sinclair et al., 2022a), a further important consideration in line with our hypotheses for secondary outcomes is that there were no significant differences in the magnitude of the improvements between the two groups. Taking into account previous observational analyses showing increased vertical GRF's and quadricep kinetics with a narrow stance width (Sinclair et al., 2022b), it could be postulated that utilization of a wide stance width would attenuate the magnitude of strength gains during this exercise. However, the findings from this investigation do not support this notion, and although it is beyond the scope of this study to extrapolate the responsible mechanisms, it can be speculated that increased focus on the posterior chain muscle groups may have served to offset any reduction in quadriceps force production (Ribeiro et al., 2022). Importantly it appears that for strength & conditioning practitioners seeking to influence squat strength adaptations through alterations in stance width, there does not appear to be any difference in between self-selected and wide-stance width groups in terms of mediating improvements in strength in the squat exercise.

A potential drawback to the current investigation is that only performance-based indices were examined during the 8-week intervention. Indices of speed, strength, agility and counter movement jump performance are important to rugby league performance (Baker & Newton, 2008; Spenanza et al., 2015) and this approach was undertaken in order to promote ecological validity and be minimally disruptive to the players pre-season training regimen. However, the measurements and observations from this investigation do not provide any direct information regarding the mechanisms responsible for the adaptations that are mediated by resistance training. Therefore, future, interventions of this nature may seek to correspondingly examine electromyographic, GRF and muscle architecture-based adaptations to better understand the effects of different resistance training interventions. A further potential limitation is the timeframe over which the intervention took place. Whilst pre-season is the period over which players are able to make the most prominent improvements in performance and anthropometric indices prior to the rigours of the playing season (Sinclair et al., 2022a), this investigation did not explore the long-term effects of the intervention groups or examine any game-based parameters. Therefore, through a future investigation it may be pertinent to examine the effects of increased squat stance width over a longer period and on longer term in season performance indices.

Conclusions

The current study adds to the current literature in strength & conditioning by examining the efficacy of wide stance width squats compared to traditional self-selected squat width during an 8-week period of pre-season training in elite rugby league players. The current investigation showed that both groups exhibited significant improvements in 505-agility test performance and 3RM squat strength but no such statistical changes in counter movement jump height. Most notably however, improvements in these parameters did not differ significantly between self-selected and wide-stance groups. As such the findings from the current randomized controlled trial suggest that there is not sufficient evidence to suggest that wide stance width squats represent a more efficacious method of resistance training prescription in elite rugby league.

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