THE EFFECTIVENESS OF STABILITY EXERCISES AND RESISTANCE TRAINING IN IMPROVING SHOULDER STABILITY AND SHOULDER STRENGTH IN SCHOOL RUGBY PLAYERS

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A dissertation submitted to the Faculty of Health Science, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of MSc Medicine in Biokinetics.

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I. Declaration

I, Limeri Smal, declare that this dissertation is my own, unaided work. It is being submitted for the MSc Medicine in Biokinetics at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other university.

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Name of candidate	Signature of candidate

5th day of **November 2025** in **Heidelberg, Gauteng**

II. Dedication

I dedicate this research paper first and foremost to God, whose grace and guidance have carried me through every challenge and triumph along this journey, reminding me of Colossians 3:23. To my parents, whose love and sacrifices have shaped me into the person I am today—your belief in me has been my greatest foundation. Thank you for always helping and supporting me in all situations.

To my incredible husband, your support, patience, and encouragement have been my strength, and I am forever grateful for you walking this path with me. Thank you for the encouragement, especially late at night when I wanted to give up. To my unborn son, whose tiny kicks reminded me daily of the purpose behind my perseverance—this is for you, a symbol of the love and dedication that I hope to pass on.

To my passion for biokinetics and my private practice, which continues to fuel my desire to heal and strengthen others, and to the rugby players I strive to help become the best versions of themselves—this work is not just mine, but for all those who trust in my knowledge and commitment.

May this journey be a stepping stone to making a difference, guided by faith, love, and purpose.

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Finally, to my family, friends, and everyone who encouraged me along this journey—your belief in me has been my greatest source of motivation. Thank you for standing by me through every challenge and triumph.

IV. Abstract

Background

The shoulder joint's high mobility makes it prone to injuries, especially in contact sports like rugby, where shoulder injuries account for 23% of cases. Adolescent players face increased risk due to developmental factors, yet most injury prevention programmes are designed for elite athletes and are too time-consuming for school players. An efficient, evidence-based targeted shoulder stability training tailored for adolescent rugby athletes is needed. This study compares the effects of stability exercises, resistance training, and a combination of shoulder stability and strength in school rugby players over six weeks.

Methodology

This randomised controlled trial was conducted at a high school's high-performance centre in Gauteng, supervised by a registered Biokineticist. A total of 160 rugby players aged 13–19 years were recruited, of whom 142 (88.8%) completed all baseline and post-protocol validated testing, yielding a 100% response rate among completers. Participants followed one of three age-appropriate six-week training protocols targeting shoulder stability (u/14–15), strength (u/16–17), or combined stability and strength (u/18–19). The control and intervention groups were divided using an odd and even number system as they wrote their names down, where the odd numbers were the control group and the even numbers were the intervention group. The training, aligned with school schedules, was performed twice weekly with progressive intensity.

Results

Across all age groups, intervention participants showed significantly greater improvements than controls ($p < 0.001$). In the stability protocol (u/14–15), the intervention group demonstrated larger gains in the Upper Quarter Y-Balance Test (mean change: left 10.9cm vs 4.4cm; right 9.3cm vs 4.1cm) and in scapular endurance and push-up capacity. In the strength protocol (u/16–17), the intervention group achieved greater improvements in 1-minute push-ups (+8.6 vs +3.5 reps) and 60% body-weight shoulder press (+6.9 vs +3.0 reps). The combined protocol (u/18–19) produced significant increases in both stability (UQYBT left +12.0 vs +3.1 cm; right

+11.2 vs +3.0 cm) and strength measures (isometric pull-up +11.1 vs +2.6 sec; 1-minute push-ups +9.3 vs +2.9 reps; shoulder press +6.1 vs +1.8 reps).

Overall, the six-week targeted protocols were effective in improving shoulder stability and strength in adolescent rugby players, with the intervention groups consistently outperforming controls.

Conclusion

This study highlights the importance of age-specific training for shoulder stability and strength in high school rugby players. Stability exercises benefit younger athletes, and a combined strength and stability training programme is most effective for mid-adolescents and older players. While structured pre-season training can enhance performance and reduce injury risk in a short time frame, factors like individual variability and external environmental factors should be considered. Future research should explore long-term effects and a broader population to refine these protocols further.

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VIII. List of Abbreviations and Definitions

1RM:	1-Repetition Maximum
BW:	Body Weight
CKCUEST:	Closed Kinetic Chain Upper Extremity Shoulder Stabilisation Test
DOMS:	Delayed-Onset Muscle Soreness
HREC:	Human Research Ethics Committee
Lat:	Latissimus Dorsi
N:	Sample Size
POPIA:	Protection of Personal Information Act
RCT:	Randomised Controlled Trial
ROM:	Range of Movement
UQYBT:	Upper Quarter Y-Balance Test

IX. Outline of this Dissertation

This dissertation complies with the requirements of the University of the Witwatersrand, Johannesburg, South Africa, for the Magister Scientiae (Medicine in Biokinetics) degree.

Chapter 1 introduces the study with an overview of the background, problem statement, aim, and objectives. It also highlights the research significance and outlines the structure of the dissertation.

Chapter 2 presents a comprehensive literature review on shoulder biomechanics, rugby-related injuries, and adolescent training considerations. It discusses neuromuscular adaptation, proprioceptive training, existing protocols, and the value of short-duration pre-season programmes, emphasising age-specific training. The search strategy is also detailed.

Chapter 3 outlines the study's methodology, describing the study design and setting, participant selection criteria, and intervention protocols, including a comparison of standard training and protocol training. It also details the testing procedures, data collection, and analysis methods, along with ethical considerations.

Chapter 4 presents the results of the study, including participant demographics and baseline characteristics, data reduction and analyses, and the outcomes of the intervention.

Chapter 5 provides an in-depth discussion of the findings, contextualising them within the existing body of literature and addressing their implications for adolescent rugby players and injury prevention strategies.

Chapter 6 concludes the dissertation by summarising the study's key findings, addressing the aims and objectives, and offering clinical and practical recommendations. It also identifies strengths and limitations of the study and suggests directions for future research.

The references used throughout the dissertation are compiled at the end of the dissertation, followed by the appendices.

CHAPTER 1

1. Introduction

1.1. Background

The shoulder joint is a marvel of human anatomy, renowned for its exceptional range of motion and the functional demands it fulfils across various activities and sports (1). As the most mobile joint in the body, the shoulder operates as a ball-and-socket joint, allowing extensive movement across multiple planes. This remarkable range is achieved through the coordinated interaction of several articulations, primarily the glenohumeral, acromioclavicular, and sternoclavicular joints. This mobility is facilitated by the interaction of stabilising structures, including ligaments, tendons, and the surrounding musculature, particularly the rotator cuff and scapular stabilisers (2). The shoulder joint's range of motion (ROM) encompasses adduction, abduction, flexion, extension, internal rotation, external rotation, and full circumduction. These movements are crucial for numerous functional tasks, yet they also render the shoulder joint particularly vulnerable to injury, especially in high-contact sports like rugby.

Rugby, characterised by its physical intensity and frequent high-impact collisions, places significant demands on athletes' shoulders. Shoulder injuries represent approximately 23% of all rugby-related injuries globally, especially among school-aged players (3). Tackling-related impacts, including direct shoulder impacts and overextension during collision, are primary mechanisms of these injuries (4). Among school-level rugby players, the risk is compounded by inadequate training, incomplete rehabilitation, and a lack of knowledge about shoulder conditioning (5).

Training protocols targeting shoulder strength, stability, and proprioception have shown promise in reducing injury rates and improving functional performance. Stability and neuromuscular training have been shown to strengthen stabilising muscles, such as the rotator cuff, improving the joint's ability to withstand repetitive stress (6, 7). Despite these potential benefits, research and protocols tailored to high school rugby players' unique physiological and developmental needs remain limited due to time factors in seasons and other priorities related to their school schedules. Therefore, this study will focus on completing a shorter time frame programme, consisting of six weeks to address these issues that arise from limited time schedules during the beginning of the school calendar.

1.2. Problem statement

Shoulder injuries pose a significant concern in rugby, especially at the school level, where adolescent athletes face unique physiological challenges, including strength imbalances, coordination issues, and uneven skeletal maturation due to rapid growth and hormonal changes (8). The high intensity and collision-based nature of rugby exacerbate this risk, with tackling and falling directly on the shoulder identified as key mechanisms of shoulder injuries (4).

Existing training protocols for shoulder stability often focus on elite athletes or adults, neglecting the developmental and practical constraints faced by high school-level players, especially in the beginning of the season when training starts (9-12). These protocols are typically time-intensive, making them unsuitable for the limited training windows available during the school rugby season. Currently, no standardised, evidence-based protocol designed for adolescent school rugby players addresses their specific needs within a short timeframe of approximately six weeks.

This gap highlights the urgent need for a structured, time-efficient programme that enhances shoulder stability and strength among school-level rugby players. A six-week pre-season protocol tailored to this demographic could potentially mitigate injury risks while optimising performance, addressing a critical need in adolescent rugby training.

1.3. Significance

This study holds significant value in addressing critical gaps in adolescent school rugby training and shoulder injury prevention by reducing shoulder injuries, tailoring the programmes more to the athlete’s age and skeletal maturation, and working to improve the athlete’s performance in a time-efficient pre-season. Furthermore, as it fills the gaps in existing research, it may improve the long-term impact on the athlete’s health and development, as well as aid with practical implications for rugby coaches and practitioners that might not have all of the training needed to work with these athletes.

1.4. Aims and objectives

The aim of this study is to compare the changes in shoulder stability and strength following a six-week intervention across three groups: those undertaking stability exercises, those undergoing resistance training, and those experiencing a combination of both, in school rugby players.

Considering the study aim, the objectives are to:

1. Determine baseline measures of shoulder stability and shoulder strength in school-level rugby players aged 13–19 years.
2. Re-test all baseline measures of shoulder stability and shoulder strength in school-level rugby players aged 13–19 years.
3. Compare the changes following six weeks of stability and/or resistance training interventions designed to improve shoulder stability and strength.

CHAPTER 2

2. Literature Review

2.1. Introduction

Rugby is characterised by high intensity and physical demands, presenting unique challenges for athletes. The sport features intermittent bouts of high-intensity activity, necessitating significant agility, aerobic fitness, speed, strength, and power (9). Research indicates that, although rugby involves 15 active players on the field, forward players (n=8) endure significantly more physical collisions than back players (n=7) during matches (10). Shoulder injuries are notably prevalent in rugby, accounting for approximately 23% of all injuries sustained during matches, particularly among school-aged players (3). The importance of robust shoulders is underscored during tackles, where players must demonstrate strength and endure considerable impacts when hitting the ground. Falling positions after tackles are linked to 32% of shoulder injuries (4).

According to Morgan (11), shoulder weakness exacerbates the risk of injury during tackles and hand-offs. This highlights the pressing need for well-conditioned shoulder strength and stability among school-level rugby players to prevent injuries and improve tackling and handling skills. Moreover, shoulder injuries often recur due to ongoing match play with existing injuries or incomplete rehabilitation (12). Gray (1) notes that while rugby players face high strength demands, school-level athletes experience additional strain due to inadequate training and limited knowledge of shoulder conditioning.

To address these challenges, various training protocols have been proposed to improve shoulder strength and stability in rugby players (13-15). Roberts (13) also suggests that shoulder ligament injuries can lead to significant consequences, often resulting in at least nine weeks of absence from the game. A study by Huxel Bliven and Anderson (6) demonstrated that incorporating stability exercises into training programmes improves shoulder stability and reduces athlete injury rates. Furthermore, a four-week randomised clinical trial by Suarez-Garcia (14) reported significant improvements ($p < 0.001$) in shoulder stability among rugby players.

It is well established that maximal strength training prompts adaptations in the nervous and muscular systems, leading to increased force production (16). Neuromuscular exercises are essential for joint stability, including strength, coordination, balance, and proprioception programme (17). Combining stability exercises with resistance training enables athletes to target multiple muscle groups and movement patterns, offering a holistic approach to shoulder conditioning. Studies examining combined training in athletes indicate significant improvements in strength and stability outcomes (7).

Given the demands of school-level rugby, where players are particularly injury-prone due to weak or unstable shoulders, there is a need for standardised protocols tailored to this demographic (5). Existing literature predominantly focuses on elite athletes or adults, leaving a gap in research addressing school-level rugby players aged 13 to 19 years (15). To the best of our knowledge, no current protocols exist for in-season school rugby players that can be completed within a six-week timeframe before the commencement of leagues and tournaments. These demographic faces unique challenges in physical development, injury susceptibility, and training readiness, underscoring the necessity for an age-appropriate programme (18).

The protocol developed in this study distinguishes itself through its duration and timing, as well as being age-appropriate. Designed to be completed in six weeks, it considers the time constraints of the school rugby season, where players have limited training opportunities before competitions begin. This intervention aims to reduce injury risks and enhance match readiness by condensing the timeframe, making training more effective during the pre-season and user-friendly for any level of high-school rugby players. While some research suggests physiological changes are more evident after 8–12 weeks of training (19, 20), other studies have observed increases in muscle size and strength after just 2–4 weeks (21-25).

2.2. Biomechanics of the shoulder joint and its role in sports

2.2.1. Anatomy and function of the shoulder joint

Understanding the biomechanics of the shoulder joint is essential for elucidating its susceptibility to injuries in high-impact sports such as rugby. The shoulder joint is a complex structure that enables an extensive range of motion while maintaining stability. The glenohumeral joint, formed by the head of the humerus and the scapula's glenoid cavity, facilitates most shoulder movements (7). Stabilisation is provided by the rotator cuff muscles (supraspinatus, infraspinatus, teres minor, and subscapularis), the glenohumeral ligaments, and the scapular stabilisers (5).

The rotator cuff plays a pivotal role in maintaining joint integrity by stabilising the humeral head within the glenoid fossa during movement and preventing excessive translations. Furthermore, scapular mobility—achieved through protraction, retraction, elevation, and depression—is crucial for smooth upper limb motion (1). These coordinated actions are particularly relevant in rugby, where players encounter rapid directional changes and high-impact tackles. Consequently, developing and maintaining shoulder strength and stability is crucial for reducing injury risk in such physically demanding activities.

2.2.2. Role of the shoulder in athletic performance

In sports performance, the shoulder joint is integral, particularly in functional activities such as throwing, tackling, and overhead movements. Rugby players rely on shoulder strength and stability to deliver powerful tackles, fend off opponents, and perform swift, high-intensity actions (10). Dynamic stability is essential for generating power and maintaining control during these actions, underscoring the importance of robust shoulder conditioning for both offensive and defensive plays (16).

Scapular mobility further enhances upper limb coordination, facilitating rapid transitions critical to gameplay (7). Effective shoulder function is essential for executing precise and responsive movements. Therefore, targeted training programmes that incorporate strength and stability exercises are indispensable for optimising performance and mitigating injury risks in rugby players (5, 17).

2.3. Injury prevalence and mechanisms in rugby

2.3.1. Shoulder injuries in rugby

Rugby is distinguished by its high injury rates, with shoulder injuries comprising a substantial proportion of match-related cases (1, 2). Kirkwood (3) reports that shoulder injuries account for approximately 23% of all rugby-related injuries, especially among school-aged players. Tackling is the primary mechanism of injury, followed by falls and collisions during gameplay. These high-impact events often exceed the shoulder's tissue tolerance, leading to ligament tears, dislocations, and labral injuries (4).

The inherent nature of rugby, involving frequent high-impact collisions and rapid movements, further exacerbates the risk of shoulder injuries (5). Dynamic interactions such as unanticipated tackles and awkward falls place significant stress on the shoulder joint, compromising its stability (4). Gabbett and Jenkins (9) highlight that the repetitive nature of these collisions contributes to cumulative joint stress, increasing the likelihood of injury over time.

2.3.2. Mechanisms of injury in high-impact scenarios

Shoulder injuries in rugby can be classified into two primary categories: acute and overuse injuries. Acute injuries occur suddenly during specific events, such as tackles or falls, while overuse injuries develop gradually due to repetitive stress. Tackling often involves high compression forces on the shoulder, necessitating both strength to absorb the impact and stability to maintain joint integrity (12).

The shoulder's vulnerability in high-impact situations arises from its role in absorbing and distributing forces during tackles. Awkward falls following tackles further amplify joint stress, contributing to approximately 32% of shoulder injuries in rugby (4).

Overuse injuries, particularly among young athletes, have increased in recent years. Year-round training and competition without adequate recovery time exacerbates the risk of conditions such as rotator cuff tendinopathy and shoulder impingement syndrome. Insufficient shoulder conditioning and strength development heighten these issues, highlighting the need for comprehensive training programmes that address both acute and chronic injury risks (3).

2.4. Considerations for adolescent athletes in shoulder training

2.4.1. Unique physiological considerations in adolescence

Adolescence is a critical phase of physical development characterised by rapid changes in strength, coordination, and body composition. During this period, growth spurts, hormonal changes, and musculoskeletal maturation significantly influence athletic performance and injury risk (8).

Uneven skeletal maturation can lead to temporary strength imbalances among different muscle groups, increasing susceptibility to injury (26). This variability in strength and coordination is particularly relevant in rugby, where precise movement patterns and quick reactions are essential. Parry (26) suggest that training protocols for adolescent athletes must account for these physiological differences to optimise performance while minimising injury risk.

2.4.2. Importance of holistic conditioning programmes

A holistic conditioning programme incorporating strength, stability, balance, and coordination is essential for adolescent rugby players. Effective training programmes should integrate strength training, flexibility exercises, and proprioceptive activities to support comprehensive physical development. Functional movements that mimic rugby-specific actions can further enhance athletic performance and reduce injury risk (6).

Core stability is crucial in developing shoulder strength and function. The core provides a foundation for efficient upper limb movement, and strengthening it improves posture and stability during high-impact activities (7). By integrating core stability exercises alongside shoulder-specific training, adolescent players can build a robust foundation for optimal performance and injury prevention.

2.4.3. The role of neuromuscular training

Neuromuscular training focuses on enhancing coordination, balance, and proprioception—key components for stable movement patterns (12). Proprioception, or the ability to perceive joint positioning, is especially critical in sports requiring quick decision-making and precise movements. Targeted proprioceptive exercises improve players' awareness of their shoulder joint positioning, enhancing stability and reducing injury risk during gameplay.

Incorporating neuromuscular training into conditioning programmes has been shown to significantly improve joint stability and function (7). For adolescent rugby players, integrating proprioceptive exercises facilitates proper movement patterns and adaptability in dynamic field situations, supporting both performance and long-term joint health.

2.5. Theoretical framework: Neuromuscular adaptation and proprioceptive training

2.5.1. Principles of neuromuscular adaptation

Neuromuscular adaptation is the body's ability to adjust to training stimuli, leading to improved strength, stability, and coordination. This process involves the nervous system's improved efficiency in recruiting motor units, boosting force production and joint stability (16).

The principles of specificity and overload are essential for promoting neuromuscular adaptation, requiring training tailored to the sport's specific demands. For rugby, exercises that mimic tackling, sprinting, and sudden bidirectional changes can enhance neuromuscular adaptations, improving both performance and resilience to injury (27).

2.5.2. Proprioceptive training and its impact on stability

Proprioceptive training is fundamental to enhancing joint stability, particularly in the shoulder. Proprioception involves sensory feedback from muscles, tendons, and joints, enabling athletes to maintain spatial awareness and coordinate movements effectively (1).

Incorporating proprioceptive training into conditioning programmes can improve awareness of shoulder joint positioning and stability during gameplay. Activities like balance board drills and stability ball exercises challenge balance and coordination, improving proprioceptive feedback and joint function (6).

2.6. Existing protocols and the value of a short-duration pre-season programme

2.6.1. Overview of current shoulder stability protocols

Current training programmes for enhancing shoulder stability often emphasise traditional strength training but lack specificity for adolescent athletes and rugby's unique demands (28). While rotator cuff and scapular stabilisation exercises are prevalent, structured, evidence-based programmes tailored for school-level rugby players are scarce.

Moreover, many protocols do not integrate neuromuscular and proprioceptive training, which is vital for developing dynamic stability in high-impact sports. Research by Wilk (7) and Huxel Bliven & Anderson (6) underscores the effectiveness of combining strength and stability training in reducing injury rates. Yet, such programmes are underutilised in school rugby contexts.

2.6.2. The necessity of a time-efficient approach

School-level athletes face time constraints due to demanding schedules, necessitating time-efficient training programmes that maximise impact within a limited timeframe (3). A six-week pre-season programme offers an optimal opportunity to enhance readiness for competition while minimising injury risks.

The proposed six-week programme is designed for seamless integration into existing training routines. It emphasises strength, stability, and proprioception, equipping players with the necessary tools to excel in rugby while mitigating injury risks. Its time-efficient design ensures accessibility for coaches and players alike, making it an ideal solution for adolescent rugby athletes.

2.7. Importance of age-specific training for rugby players

Training programmes tailored to rugby players' age and developmental stage are essential for safety and effectiveness, considering the varying physical and physiological changes during adolescence.

Age-specific training ensures that rugby players develop the physical attributes required for their growth stage while minimising injury risks. Younger players focus on foundational stability, middle adolescents transition to size and strength development, and older adolescents adopt a comprehensive training approach to meet the demands of competitive rugby. This progression promotes both player safety and long-term athletic development.

2.7.1. Age 13–14: Focus on stability and fundamental movements

Adolescents aged 13–14 experience rapid growth spurts, which can lead to temporary strength imbalances and reduced coordination (8). At this stage, the skeletal system remains immature, and heavy-weight training may place undue stress on growth plates, increasing the risk of injury (29).

Training for this age group should prioritise stability exercises, neuromuscular coordination, and functional movement patterns. Bodyweight exercises, resistance band work, and proprioceptive drills are effective in building foundational strength and motor skills, creating a solid base for advanced training in later years (6).

2.7.2. Age 15–16: Transition to building size and strength

By ages 15–16, most adolescents achieve greater skeletal maturity and muscle development, making this a critical period for hypertrophy and strength training (30). Moderate weight training with an emphasis on progressive overload is appropriate for developing muscle size and strength.

Proper technique and sport-specific strength exercises should be integrated to prepare players for rugby's physical demands of rugby, including tackling and scrummaging, which require greater muscle mass and power (31).

2.7.3. Age 17–19: Comprehensive strength and stability training

Players aged 17–19 years face the highest physical demands due to their involvement in competitive rugby. At this stage, a balanced approach that integrates weight training for strength and power with stability exercises for joint health is crucial (7).

Stability-focused activities, such as scapular stabilisation and core strengthening, reduce the risk of injuries caused by the high-impact forces of tackling and collisions. Neuromuscular training further enhances proprioception, improving dynamic joint stability during gameplay (6).

2.8. Research gaps

Table 2.1: Previous interventions

Study (Year)	Population	Intervention	Comparison	Outcomes	Key Findings
Hislop et al., 2016 – BMJ Open Sport Exerc Med (32)	40 schoolboy rugby teams (U15–U18, UK)	Cluster RCT – Movement control exercise programme (balance, trunk,	Usual warm-up routine	Incidence of match and training injuries	Significant reduction in overall match injuries (RR 0.72, $p < 0.05$); trend

		shoulder, lower limb control) integrated in warm-ups (pre-activity IPEP, 20 min)			toward fewer upper-limb injuries
Hislop et al., 2017 – Br J Sports Med (33)	81 schoolboy teams (U15–U18, UK)	Cluster RCT – Movement control injury prevention programme (Activate warm-up with shoulder/scapular control)	Standard warm-up	Musculoskeletal & concussion injury rates	72% reduction in upper-limb injuries among players who performed the programme ≥3×/week
Suarez-García et al., 2021 – J Men's Health (14)	30 federated male rugby players (mean age 23 ± 3 yrs)	RCT – 4-week plyometric + proprioceptive + strength programme (BodyBlade, elastic bands, push-ups) twice weekly	Control (no special programme)	Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST), Y-Balance test	Significant improvement in shoulder stability and upper-limb control ($p < 0.05$) maintained after 4 weeks
Salles et al., 2015 – J Athlete Train (34)	30 active adults	RCT – 6-week strength training of shoulder rotators (elastic bands, dumbbells)	Control (no training)	Shoulder joint position sense (proprioception)	Improved proprioceptive accuracy and strength in trained group ($p < 0.05$)
Attwood et al., 2017 – Br J Sports Med (35)	16 adult community rugby teams	Cluster RCT – Neuromuscular "movement control" warm-up programme (Activate)	Usual warm-up	Match injury incidence	40% reduction in upper-limb injuries (IRR 0.60, $p = 0.04$)
Barden et al., 2022 – World Rugby Report (36)	School rugby teams (implementation study)	Programme evaluation – Activate injury prevention warm-up (scapular, trunk, lower limb)	—	Feasibility, adherence, injury reporting	High coach acceptance but low adherence reduced effectiveness; improved when embedded into regular warm-ups
West et al., 2023 – Sports Med (Systematic Review) (37)	Youth rugby (U13–U19)	Systematic review / meta-analysis of injury prevention RCTs	—	Injury incidence, prevention strategies	Movement-control and strength programmes reduce overall injury risk by 26–40%; shoulder

					data limited but trends positive
Schwank et al., 2022 – JOSPT (Consensus Statement) (38)	Multisport / Rugby contexts	Expert consensus – load & risk management for shoulder injury	—	Prevention & return-to-play guidance	Recommends integrated strength + neuromuscular control training and progressive loading for shoulder health

Evidence from schoolboy RCTs (32, 33) shows movement control and stability warm-ups significantly reduce injury rates, including shoulder injuries. Suarez-García *et al*. (14) RCT directly shows improved shoulder stability from combined plyometric with proprioceptive, and strength training, confirming physiological benefits in rugby players. Salles *et al*. (34) provides mechanistic evidence that resistance training improves proprioception, supporting stability outcomes. Adult/community rugby RCTs (35) mirror these benefits, reinforcing the intervention's relevance to youth sport. Reviews and consensus statements (37, 38) recommend combining strength with neuromuscular stability as best practice for injury prevention. Implementation studies highlight that coach education and adherence are crucial for real-world success in school environments.

Integrating these elements, this protocol addresses the specific needs of school-level rugby players, filling a crucial gap in the literature and equipping coaches and practitioners with a valuable tool for optimising performance while mitigating injury risks. The primary objective of this study is to evaluate the effectiveness of a six-week protocol in improving shoulder stability and strength among school-level rugby players aged 13 to 19, while each age group follows its tailored programme.

2.9. Search strategy

A comprehensive review informed the development of the theoretical framework and age-specific training guidelines of peer-reviewed literature and relevant resources. PubMed, Scopus, and Google Scholar were used to identify studies on neuromuscular adaptation, proprioceptive training, and age-specific training in adolescent athletes. Search terms included combinations of keywords such as “neuromuscular adaptation”, “proprioceptive training”, “shoulder stability”, “adolescent training programmes”, “rugby conditioning”, “age-specific strength training”, and “dynamic stability”.

Articles were selected based on their relevance to rugby-specific training, injury prevention, and adolescent development. Priority was given to studies published within the last 15 years, though seminal works were also included. Additional references were sourced from cited works within these articles, ensuring a thorough and evidence-based approach to developing training protocols and theoretical insights.

CHAPTER 3

3. Methodology

3.1. Study design

Randomised controlled intervention trial.

3.2. Study setting

The research was conducted at a high school's high-performance centre, located in Gauteng, on the school grounds where participants conduct their weekly exercises. All tests and exercises were completed and supervised by a registered Biokineticist who has been operating the facility and working with the participants for over five years. No additional or external infrastructure was required for this study.

3.3. Participants

3.3.1. Population of the study

The study employed a convenience sampling technique. Participants were male rugby players from a Gauteng-based high school aged between 13 and 19. Based on their age category, participants were assigned into three main groups: stability exercises (under 14 and 15), resistance training (under 16 and 17), and a combination of stability exercises and resistance training (second and first teams, consisting of 17–19-year-olds).

3.3.2. Sample size

Each main group consisted of at least 40 players (n=120). Twenty players per main group were randomly selected to follow the proposed six-week protocol (termed "intervention group"). At the same time, the other 20 players continued with their normal training programme (termed "control group"), thus forming two sub-groups.

3.3.3. Sample selection

A free number selection generator application, available on the Android Play Store, was used to divide the list of participants into two groups: even numbers and odd numbers. The study was conducted as a blinded process for the participants to ensure unbiased participation and effort.

3.4. Inclusion and exclusion criteria

The study used the following inclusion and exclusion criteria presented in Table 3.1 below.

Table 3.1: Inclusion and exclusion criteria of the participants

3.4.1. Inclusion Criteria	3.4.2. Exclusion Criteria
Rugby team players from a Gauteng-based high school for the year 2024	Any participants with a current shoulder injury
Aged between 13 and 19 years old	Any participant who became ill and used medication that could affect muscle strength, bone health, or in any way impact the study outcome

3.5. Intervention

The intervention was run over 6 weeks, aligning with the typical availability in high school calendars for preparation before leagues and tours. This timeframe is considered optimal for the proposal, potentially offering significant benefits to the future of school rugby. Research suggests physiological changes are more evident after 8–12 weeks of training (19, 20), but other studies observed an increase in muscle size and strength after 2–4 weeks (21-25).

The study consisted of three protocols, each comprising specific weekly exercise sessions (see Appendix 1).

3.6. Testing procedure

Participants who had handed in their consent forms and qualified to participate were tested during their first booked session time. Subsequently, they performed the protocol twice a week for six weeks (see Appendix 1).

A whistle with a handheld stopwatch will be used for the pre- and post-measurements.

The same tests were repeated after the six-week protocols, following the same order as in the initial testing. Table 3.2 represents the order in which each was conducted per protocol.

Table 3.2: Order of tests conducted per protocol

Order	Protocol 1	Protocol 2	Protocol 3
1	UQYBT	Isometric Pull-Up	UQYBT
2	Scapular Retraction	Shoulder Press	Isometric Pull-Up
3	Push-Up Plus	1-minute Push-Up	Scapular Retraction
4	CKCUEST		Shoulder Press
5			Push-Up Plus
6			1-minute Push-Up
7			CKCUEST

Abbreviations: UQYBT: Upper Quarter Y-Balance Test; CKCUEST: Closed Kinetic Chain Upper Extremity Stability Test

3.6.1 Shoulder stability

Upper Quarter Y-Balance Test (UQYBT) (39): A functional test performed on a Y-shaped board to assess upper body stability and dynamic balance. The participant, in a plank position at the centre of the board, reaches their arm medially, inferior laterally, and superior laterally. The distances reached are recorded. This test has instructions on how to set up and measure it for the best accuracy. Figure 3.1 shows how the UQYBT will look from a superior view when testing the right shoulder versus the left.

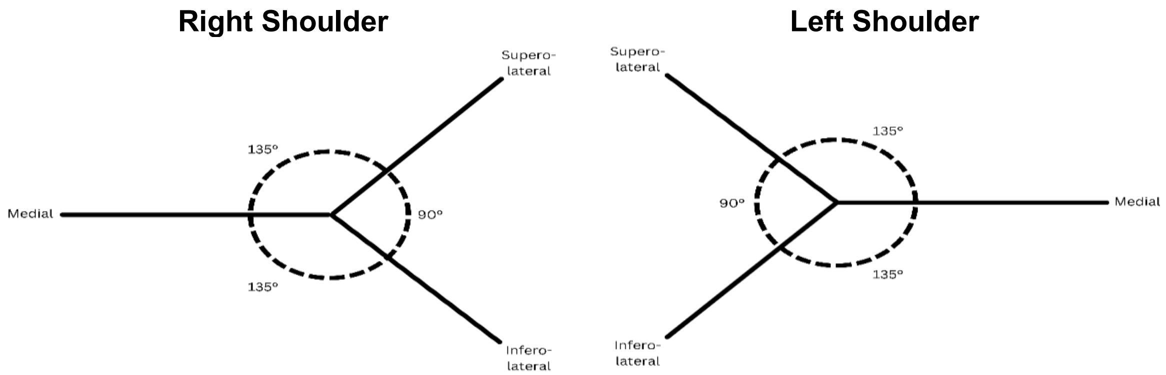

Figure 3.1: Upper Quarter Y-Balance Test (UQYBT). *Testing the shoulder which is being stood on. Three planes per side are being tested which include the medial, superolateral and inferolateral sides. Image created by the author using Canva, 2025.*

Scapular Retraction Test (40): Assesses the strength and endurance of the scapulae retracting muscles (shoulder blades). The participant pulls a resistance band towards their body with arms extended in front, keeping their shoulders down and back. The duration of the hold is recorded. The participants will stand two meters away from the anchor point of the elastic used. The same resistance elastic (JSSA - JumpStretch SA, light purple elastic) will be used during the retest time to ensure accuracy. Figure 3.2 demonstrates the pulling angle for the Scapular Retraction Test.

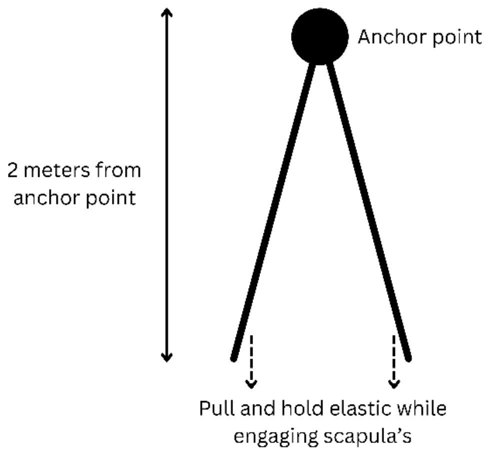

Figure 3.2: Scapular Retraction Test. *Image created by the author using Canva, 2025.*

Push-up Plus Test (41): Involves performing a push-up and, at the top of the movement, protracting the shoulder blades as far as possible. The number of repetitions until failure is recorded to assess scapular stability maintenance. Figure 3.3 demonstrated the protraction of the scapulae during the Push-up Plus test.

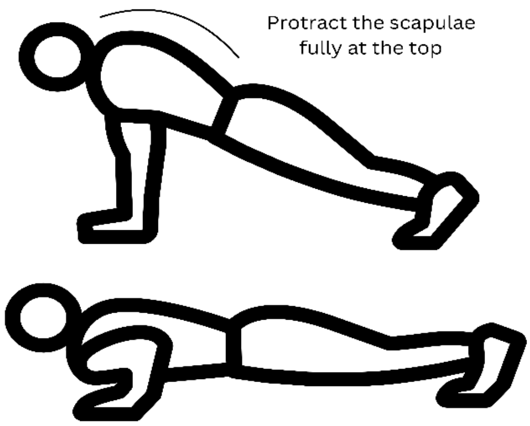

Figure 3.3: Push-Up Plus Test. *Image created by the author using Canva, 2025.*

Closed Kinetic Chain Upper Extremity Shoulder Stabilisation Test (CKCUEST) (42): Requires two strips of athletic tape placed parallel to each other 90 cm apart on the floor. The participant, starting in a push-up position with one hand on each tape, reaches across the body to touch the opposite hand and returns to the starting position. The process is repeated with the other hand. Touches are counted with each cross-body reach within a 15-second trial. After a warm-up trial, three test trials are performed with 45 seconds of rest in between, and the average of the three trials is recorded as the test score. Figure 3.4 Demonstrates the starting position of the CKCUEST. Participants must alternate and tap the opposite hand as fast as possible.

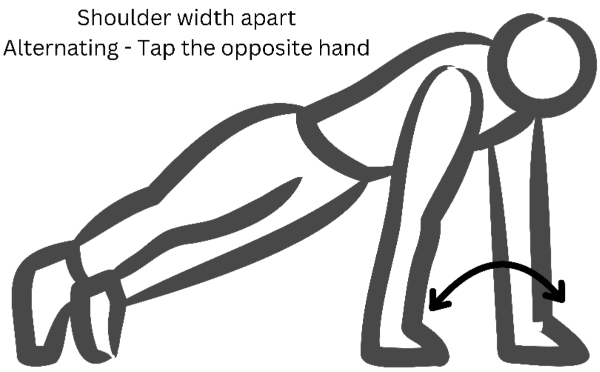

Figure 3.4: Closed Kinetic Chain Upper Extremity Shoulder Stabilisation Test. *Image created by the author using Canva, 2025.*

3.6.2 Shoulder resistance

Isometric Pull-up Test (43): This test evaluates the individual's capacity to maintain a static position during a pull-up, which places a significant demand on the shoulder muscles. The participant grips a pull-up bar with their palms facing away from their body and their elbows flexed at 90 degrees. They then lift their feet off the ground and hold their body in a static position for as long as possible. The duration of the hold is recorded as the test score. Figure 3.5 demonstrates how to perform the Isometric Pull-up test.

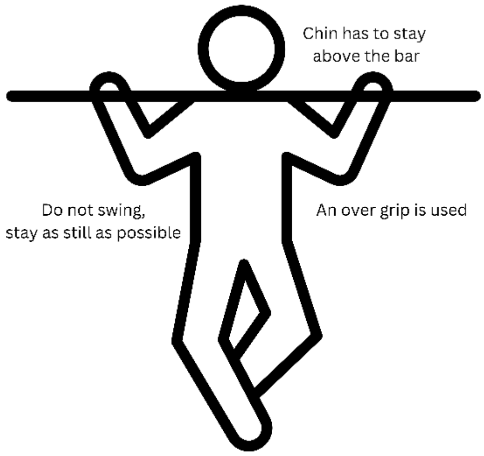

Figure 3.5: Isometric Pull-up Test. *Image created by the author using Canva, 2025.*

<u>One-minute Push-ups Test (44)</u>: This test measures shoulder strength and endurance. The individual begins in a plank position with hands and toes on the floor, hands should be shoulder-width apart. They lower their body towards the floor, keeping the elbows close to the body, then push up back to the starting position. This movement engages the shoulder muscles extensively. The total number of push-ups performed in one minute is recorded as the test score. Figure 3.6 demonstrates the 1-Minute Push-up test. Participants are not allowed to touch the floor with their chest or knees – this will count as a failure of the test. Elbows have to stay as close as possible to their body.

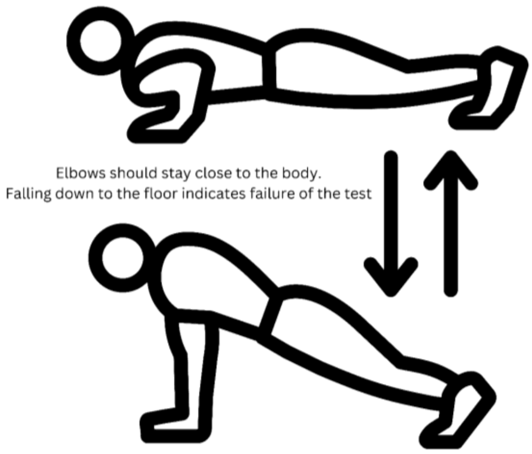

Figure 3.6: 1-Minute Push-up Test. *Image created by the author using Canva, 2025.*

<u>Shoulder Press (45)</u>: A weightlifting exercise that measures shoulder strength by pressing a weight overhead from shoulder height. The test score is the number of repetitions at 60% of the participant's estimated 1RM, calculated based on their body weight. The participants will have to do each repetition with the bar lowered to their

chin and press up to straighten their arms. Figure 3.7 demonstrates a barbell shoulder press. The barbell must be loaded at 60% of the participant's body weight. Only proper presses were considered, and the participants were able to fully extend their elbows.

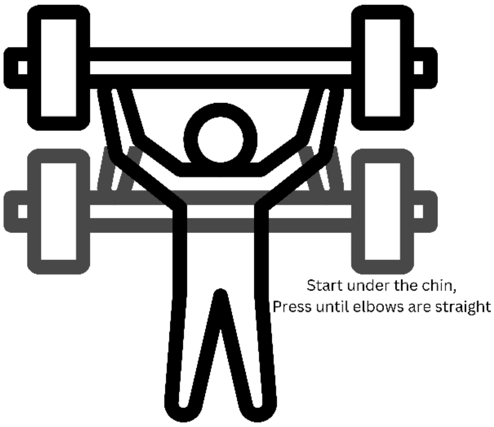

Figure 3.7: Barbell Shoulder Press. *Image created by the author using Canva, 2025.*

Strength and conditioning coaches advise rugby players not to lift weights until they are 16 years old (18). Thus, Protocol 1 was designed for 13- to 14-year-olds since they are still growing, and this protocol only involves body weight. Protocol 2 involved only weight training exercises for 15- to 16-year-olds since the players can now start with weight-loading exercises to reach optimal muscle mass. Protocol 3 combined protocols 1 and 2 for full shoulder strength training and stability capability.

3.7. Standard training vs protocol training

Standard strength and conditioning sessions focus on the upper body as well as the lower body instead of focusing on specific muscle groups during the sessions. The standard sessions were completed once a week instead of twice, which means that the players had fewer days to train everything that was needed. Due to the time limits at the beginning of the high school calendars, the coaches would rather skip the conditioning sessions and work on the team’s skills.

The exercises involved caused fatigue and discomfort, especially at the beginning of the protocols. The participants did stretches after each session to minimise these discomforts. All weights involved were monitored closely to ensure the participants did not use weights considered too heavy for their body weight. Appendix 1 outlines all three protocols as well as the exercises involved during the six weeks.

3.7.1. Stability protocol (Protocol 1)

Incorporate proprioceptive training (e.g., ball push-ups, ball planks), plank variations (side plank on the elbow and straight arm, planking with alternating arm lifts), prone Y's and T's, prone circles, elbow to straight arm plank movements, and isometric push-ups. Exercises were conducted in a circuit format with increasing time intervals. Participants were expected to complete two rounds, consisting of two sets with 30–60 seconds per repetition by the end of the 6 weeks. Table 3.3 demonstrates the training programme used during Protocol 1. Table 3.3 demonstrates the total layout of Protocol 1 over the six weeks.

Table 3.3: Protocol 1: Stability training

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Exercises	Ball push-ups, ball planks, side plank (elbow / straight arm), plank with alternating arm lifts, prone Y's and T's, prone circles, elbow to straight arm plank, and isometric push-ups					
Time (s)	30	35	40	45	50	60
Sets	2	2	2	2	2	2

3.7.2. Resistance protocol (Protocol 2)

Featured flat and incline dumbbell presses, resisted push-ups with an elastic or weight, seated and standing shoulder presses, bent-over rows with variations of a neutral dumbbell grip, barbell over grip and barbell reverse grip, upright rows, and battle ropes with variations of single-arm, alternating and bilateral. Participants started with lower weights, gradually increasing the weight from 50% to at least 80% of their 1-repetition maximum (1RM) by the study's conclusion. The protocol prescribed three to five sets of 8–12 repetitions for each weight exercise. Battle ropes were increased by 5 repetitions per side. Table 3.4 demonstrates the layout of Protocol 2 over the six weeks.

Table 3.4: Protocol 2: Resistance training

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Exercises	Dumbbell bench press (flat / incline), resisted push-ups (weight / elastic), dumbbell shoulder press (seated / standing), bent-over rows (dumbbell neutral grip / barbell over grip / barbell reverse grip), upright rows, battle ropes (single arm / alternating / bilateral)					
Sets	3	3	4	4	5	5
Weight Repetitions	8	8	10	10	12	12
Battle Ropes	25	30	35	40	45	50
Weight (%BW to 1RM)	50	60	65	70	75	80

3.7.3. Combination of stability and resistance protocol (Protocol 3)

Combination exercises from both the Stability and Resistance Protocols, including ball push-ups, ball planks, plank variations (side plank on the elbow and straight arm, planking with alternating arm lifts), prone Y's and T's, prone circles, elbow to straight arm plank movements, and isometric push-ups, and flat and incline dumbbell presses, resisted push-ups with an elastic or weight, seated and standing shoulder presses, bent-over rows with variations of a neutral dumbbell grip, barbell over grip and barbell reverse grip, upright rows, and battle ropes with variations of single-arm, alternating and bilateral. Participants alternated between resistance training and stability exercises within each workout session, designed to target specific muscles and movements essential for shoulder strength and stability in rugby players.

Participants were expected to complete one round, consisting of three to five sets with 30–60 seconds per repetition for the stability training. For the resistance training participants started with lower weights, gradually increasing the weight from 50% to at least 80% of their 1-repetition maximum (1RM) by the study’s conclusion. The protocol prescribed three to five sets of 8–12 repetitions for each weight exercise. Battle ropes were increased by 5 repetitions per side per week.

Table 3.5 demonstrates the combination layout of Protocols 1 and 2 over the six weeks.

Table 3.5: Protocol 3: Combination of stability and resistance training

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Exercises	Ball push-ups, ball planks, side plank (elbow / straight arm), plank with alternating arm lifts, prone Y's and T's, prone circles, elbow to straight arm plank, and isometric push-ups					
Time (s)	30	35	40	45	50	60
Sets	3	3	4	4	5	5
Exercises	Dumbbell bench press (flat / incline), resisted push-ups (weight / elastic), dumbbell shoulder press (seated / standing), bent-over rows (dumbbell neutral grip / barbell over grip / barbell reverse grip), upright rows, battle ropes (single arm / alternating / bilateral)					
Sets	3	3	4	4	5	5
Weight Repetitions	8	8	10	10	12	12
Battle Ropes	25	30	35	40	45	50
Weight (%BW to 1RM)	50	60	65	70	75	80

3.8. Ethical considerations

3.8.1. Sample and data use and management, storage, and disposal

Ethical clearance was applied from the Human Research Ethics Committee (Medical) (HREC), University of the Witwatersrand (Appendix 2). Permission to access the players was obtained from the school principal of a Gauteng high school (Appendix 3). All potential participants were provided with information sheets (Appendix 4), and informed consent forms were distributed to parents and guardians (Appendix 5), along with consent or assent forms for the participants themselves (Appendix 6 and 7). Participation in this study was contingent upon receiving these consent forms, ensuring that all participants and their guardians were fully informed and agreed to the study's procedures before commencement.

The exercise protocol has caused participants to experience muscle fatigue and stiffness. To relieve some discomfort, stretches were performed after each session. Participants and their guardians needed to be informed about the possible discomforts associated with the study to address any potential concerns.

Data was securely stored in a private office, accessible solely to the Biokineticist overseeing the study. Additionally, the Biokineticist and the study supervisors were the only individuals accessing the collected data. For data analysis and storage purposes, the biokineticist compiled the results into an Excel file (Appendix 8).

To further ensure the security and confidentiality of the data, it was retained in code format in cloud storage for a minimum of five years, adhering to data protection and privacy guidelines. Should any participant wish to see their results, it was made available upon completion of the study. Additionally, if a guardian requests to view the participant's results, this was only permitted with the participant's explicit consent, ensuring compliance with the Protection of Personal Information Act (POPIA) and respecting the privacy and autonomy of each participant.

3.9. Data analyses

Statistica version 14.2 (StataSoft Inc., Tulsa, OK, USA) was used for all statistical analysis. Statistical significance was set at $p < 0.05$. Normally distributed continuous variables will be presented as mean ± standard deviation (SD). The Absolute Change was recorded per measurement. A repeated measures analysis of variance was used to compare the effect of the intervention on the intervention group after a six-week follow-up.

CHAPTER 4

4. Results

4.1. Baseline measures

At baseline, all participating rugby players (aged 14–19 years) underwent initial tests based on the specific protocol assigned to their respective age groups. Each protocol was designed to evaluate key aspects of shoulder function relevant to their developmental stage and training demands.

Protocol 1: Designed for 14–15-year-old rugby players, this protocol assessed shoulder stability through a series of standardised tests, which included the Upper Quarter Y-Balance Test (UQYBT), Push-up Plus test, Scapular Retraction test and the Closed Kinetic Chain Upper Extremity Shoulder Stabilisation Test (CKCUEST).

Protocol 2: Applied to 16–17-year-old rugby players, this protocol focused on evaluating shoulder strength using appropriate resistance-based tests, which included the Isometric Pull-up test, 60% Body Weight Shoulder Press test, and the 1-minute Push-ups test.

Protocol 3: Administered to 18–19-year-old rugby players, this protocol incorporated both shoulder stability and strength tests, providing a comprehensive evaluation of upper-body function in this age group. All the tests that were conducted in protocols 1 and 2 were used in Protocol 3, that is, the Upper Quarter Y-Balance Test (UQYBT), Push-up Plus test, Scapular Retraction test and the Closed Kinetic Chain Upper Extremity Shoulder Stabilisation Test (CKCUEST) for shoulder stability and the Isometric Pull-up test, 60% Body Weight Shoulder Press test, and the 1-minute Push-ups test for strength.

These baseline measures established a foundation for assessing the impact of the respective training interventions and allowed for comparative analysis between pre- and post-protocol results.

4.2. Adherence and response rate

A total of 160 rugby players were initially recruited for the study. Of these, 142 (88.75%) fully adhered to their assigned protocol (either the control group or intervention group), completing all required testing and training sessions. The adherence rate was high across all protocol groups, with most participants remaining committed to the study despite various external factors such as academic commitments, provincial rugby obligations, and personal reasons, contributing to the 18 players with unusable data. The final group numbers are presented in Table 4.1.

Table 4.1: Protocol group numbers and total dropouts

Protocol	Intervention group			Control group			Total used data
	Initial test	Retest	Dropouts	Initial test	Retest	Dropouts	
Protocol 1	30	28	2	31	28	3	56
Protocol 2	22	20	2	22	20	2	40
Protocol 3	27	23	4	28	23	5	46
Total	79	71	8	81	71	10	142

It was observed that some participants in the control groups also engaged in extra gym sessions and exercises as part of their routine. This additional activity outside of what constituted their standard training programme could have influenced the results observed in the control groups. According to the methodology, the control groups were intended to continue with their regular training, which typically involved less frequent and less specifically targeted strength and conditioning sessions compared to the intervention protocols. The fact that some control participants undertook extra work, potentially similar to elements of the intervention protocols, means that their improvements might not solely reflect the impact of their standard training. This could have potentially reduced the observed differences between the intervention and control groups, making it more difficult to isolate the true effectiveness of the stability and resistance training protocols implemented in this study.

In terms of data completeness, all 142 participants who adhered to the protocol also provided usable data for both baseline and post-protocol testing, resulting in a 100% response rate for the participants who completed the programme. This high response rate allows for a comprehensive analysis of the protocols' impact across all age groups.

4.3. Changes after six weeks

All of the rugby players were re-tested after 6 weeks. All of the tests were performed in the same initial sequence. The absolute change and average change percentage have been calculated to illustrate the extent of improvement within the groups.

4.3.1 Protocol 1 results

Tables 4.2 and 4.3 represent the results of the UQYBT from Protocol 1 between the control group and the intervention group. The average total of measurements in Table 4.3 was calculated using the following formula:

$$\frac{\text{Medial} + \text{Superolateral} + \text{Inferolateral}}{3}$$

Table 4.2: Protocol 1: u/14 and u/15 UQYBT results

	Control	Intervention	Control	Intervention	Control	Intervention
Right Arm Reach	**Medial**	**Medial**	**Superolateral**	**Superolateral**	**Inferolateral**	**Inferolateral**
Baseline test (cm)	102.18±10.53	105.04±8.28	56.64±13.27	61.43±8.60	63.5±11.23	72.32±9.24
Follow-up test (cm)	105.04±9.60	114.25±6.78	62.04±10.93	70.29±8.38	67.4±10.70	82.18±7.75
Mean absolute change (cm)	2.86	9.21	5.39	8.86	3.96	9.86
p-value	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*
Left Arm Reach	**Medial**	**Medial**	**Superolateral**	**Superolateral**	**Inferolateral**	**Inferolateral**
Baseline test (cm)	101.11±10.45	104.0±11.12	62.29±15.98	66.5±10.84	61.96±10.40	65.6±11.53
Follow-up test (cm)	104.68±9.41	113.96±8.20	67.46±14.50	77.64±10.94	66.43±10.09	77.21±10.35
Mean absolute change (cm)	3.57	9.93	5.18	11.18	4.46	11.57
p-value	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*

*Data presented as mean±SD; *p < 0.05 are statistically significant*

Table 4.3: Protocol 1: u/14 and u/15 UQYBT total measurements results

	Control		Intervention	
Arm Reach	**Left**	**Right**	**Left**	**Right**
Baseline test (cm)	75.12	74.11	78.7	79.6
Follow-up test (cm)	79.52	78.16	89.60	88.91
Mean absolute change (cm)	4.40	4.05	10.90	9.31

As shown in Tables 4.2 and 4.3, the intervention group demonstrated significant improvements in the UQYBT compared to the control group ($p < 0.001$). The mean absolute change in the total reach distance was significantly higher for the intervention group (left: 10.90cm, right: 9.31cm) compared to the control group (left: 4.40cm, right: 4.05cm). Figure 4.1 visually represents these improvements across the medial, superolateral, and inferolateral reach directions for both arms.

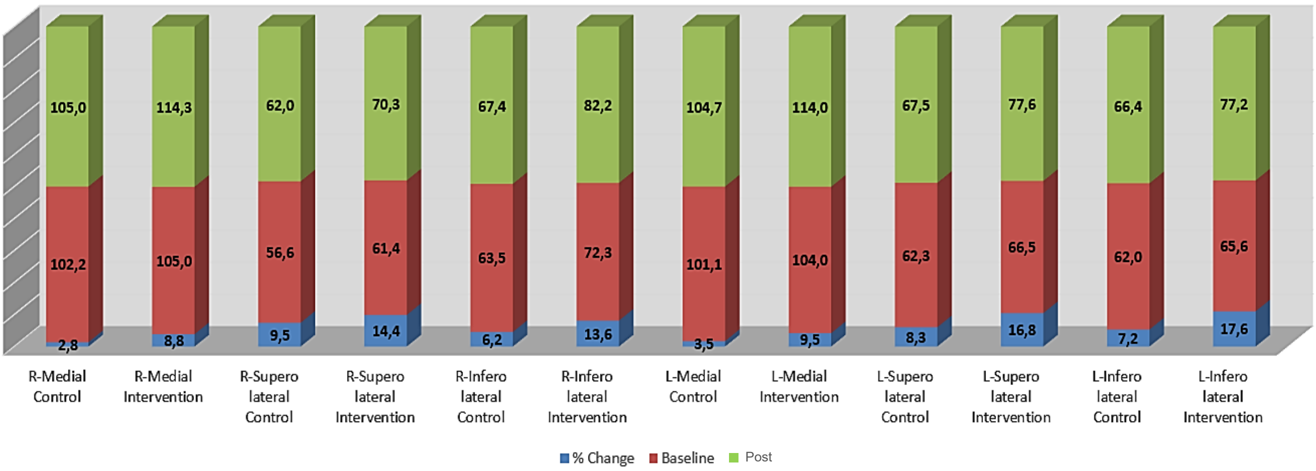

Figure 4.1: Protocol 1: Upper Quarter Y-Balance Test (UQYBT). *The* ***UQYBT*** *includes 6 planes that were tested – Left and right arm reach: Medial, Superolateral and Inferolateral. The test is measured in centimetres.*

Table 4.4 and Figure 4.2 represent the results for the remaining shoulder stability tests (i.e., the Scapular Retraction test, the Push-up Plus test, and the Upper Extremity Shoulder Stabilisation Test [CKCUEST]). The intervention group showed statistically significant improvements ($p < 0.001$) in the Scapular Retraction Test (mean absolute change: 10.86 seconds vs 1.17 seconds for the control) and the Push-up Plus Test (mean absolute change: 9.71 repetitions vs 4.50 repetitions for the control). While the control group showed a non-significant ($p = 0.9$) change in the CKCUEST, the intervention group had a significant improvement ($p < 0.001$) with a mean absolute change of 4.98 repetitions**.**

Table 4.4: Protocol 1: u/14 and u/15 Shoulder stability tests results

	Control	**Intervention**	**Control**	**Intervention**	**Control**	**Intervention**
	Scapular Retraction (sec)	**Scapular Retraction (sec)**	**Push-up Plus (reps)**	**Push-up Plus (reps)**	**CKCUEST (reps)**	**CKCUEST (reps)**
Baseline test	5.22±6.87	4.55±4.95	12.25±6.28	12.25±6.82	17.63±3.33	17.99±3.12
Follow-up test	6.92±7.26	15.41±7.16	16.75±6.60	21.96±6.24	17.68±2.73	22.96±2.07
Mean absolute change	1.17	10.86	4.50	9.71	0.05	4.98
p-value	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.9	< 0.001*

*Data presented as mean±SD; *p < 0.05 are statistically significant; Abbreviations: CKCUEST: Closed Kinetic Chain Upper Extremity Stability Test*

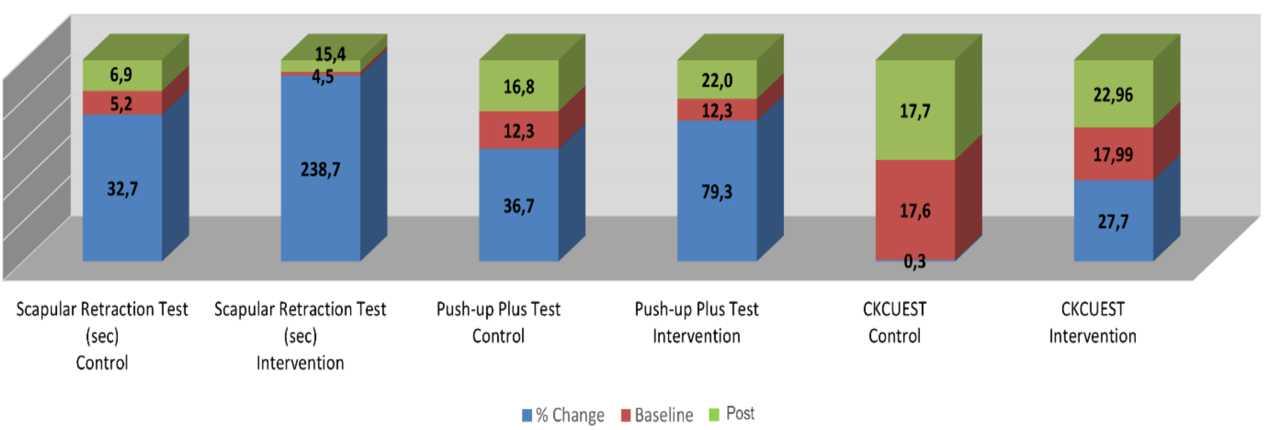

Figure 4.2: Protocol 1: Shoulder stability tests. *The tests include the Scapular Retraction test, which is done in seconds, the Push-up Plus test, which is done in repetitions completed, and the Upper Extremity Shoulder Stabilisation Test (CKCUEST), which is done in repetitions completed.*

4.3.2 Protocol 2 results

Table 4.5 and Figure 4.3 present the results of the shoulder strength tests that were conducted in Protocol 2, which includes the Isometric Pull-ups Test, the 60% Body Weight Shoulder Press Test, and 1-minute Push-ups Tests.

Table 4.5: Protocol 2: u/16 and u/17 Strength tests results

	Control	**Intervention**	**Control**	**Intervention**	**Control**	**Intervention**
	Isometric Pull-up (sec)	**Isometric Pull-up (sec)**	**1-min Push-ups (reps)**	**1-min Push-ups (reps)**	**Shoulder Press (reps)**	**Shoulder Press (reps)**
Baseline test	31.18±17.66	29.91±20.15	41.30±14.49	40.45±12.05	6.92±4.94	6.62±5.05
Follow-up test	30.31±17.36	33.77±20.72	44.80±13.77	49.00±21.14	9.96±5.94	13.55±7.33
Mean absolute change	-0.87	3.86	3.50	8.55	3.04	6.94
p-value	< 0.597	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*

*Data presented as mean±SD; *p < 0.05 are statistically significant*

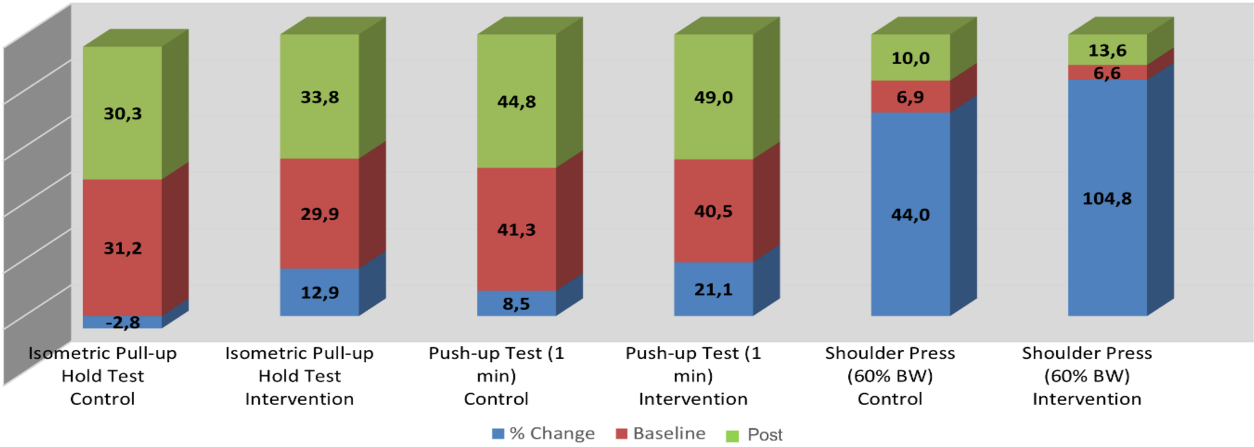

Figure 4.3: Protocol 2: Shoulder strength tests. *Tests include the Isometric Pull-up test done in seconds, the 1-minute Push-ups test done with a repetition count, and the 60% BW Shoulder Press test.*

The resistance training protocol (Protocol 2) for the u/16 and u/17 rugby players led to significant improvements ($p < 0.001$) in all strength measures for the intervention group compared to the control group. In the Isometric Pull-up Test, the intervention group showed an average improvement of 3.86 seconds, while the control group experienced a slight regression of 0.87 seconds—notably, the p-value ($p = 0.597$) is not considered statistically significant. In the 1-minute Push-ups Test, the intervention group demonstrated a greater gain with an average of 8.55 additional repetitions, while the control group improved by only 3.50 repetitions. The 60% body weight Shoulder Press saw a more significant disparity, with the intervention group achieving an average increase of 6.94 repetitions compared to the control group's improvement of 3.04 repetitions. A few rugby players in the intervention group who could not initially shoulder press 60% of their body weight could complete at least 1 repetition by the end of the six-week protocol. These findings collectively suggest that the six-week resistance training programme was effective in enhancing the shoulder strength of the intervention group in multiple measures.

4.3.3 Protocol 3 results

Tables 4.6 and 4.7 represent the UQYBT results for the u/18 and u/19 rugby players. Similar to Protocol 1, the intervention group showed significant improvements ($p < 0.001$) in UQYBT reach distances compared to the control group. The mean absolute changes in total reach distance were: Left: 11.99cm (intervention) vs 3.11cm (control); and right:

11.19cm (intervention) vs 3.02cm (control). These improvements are visually represented in Figure 4.4.

Table 4.6: Protocol 3: u/18 and u/19 UQYBT results

	Control	Intervention	Control	Intervention	Control	Intervention
Right Arm Reach	**Medial**	**Medial**	**Superolateral**	**Superolateral**	**Inferolateral**	**Inferolateral**
Baseline test (cm)	108.91±11.09	110.52±10.73	65.91±10.52	64.78±7.98	73.61±13.19	75.00±13.42
Follow-up test (cm)	112.00±11.43	119.48±8.82	69.09±10.35	76.96±9.08	76.39±12.46	87.43±9.40
Mean absolute change (cm)	3.09	8.96	3.17	12.17	2.78	12.43
p-value	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*
Left Arm Reach	**Medial**	**Medial**	**Superolateral**	**Superolateral**	**Inferolateral**	**Inferolateral**
Baseline test (cm)	109.04±10.33	111.04±11.30	68.91±7.83	65.39±8.14	72.35±11.05	72.87±12.76
Follow-up test (cm)	111.87±10.30	119.70±9.23	72.35±7.32	78.17±10.09	75.39±10.61	87.39±8.16
Mean absolute change (cm)	2.83	8.65	3.43	12.78	3.04	14.52
p-value	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*

*Data presented as mean±SD; *p < 0.05 are statistically significant*

Table 4.7: Protocol 3: u/18 and u/19 UQYBT total measurements results

	Control		Intervention	
Arm Reach	**Left**	**Right**	**Left**	**Right**
Baseline test (cm)	83.43	82.81	83.10	83.43
Follow-up test (cm)	86.54	85.83	95.09	94.62
Mean absolute change (cm)	3.11	3.02	11.99	11.19

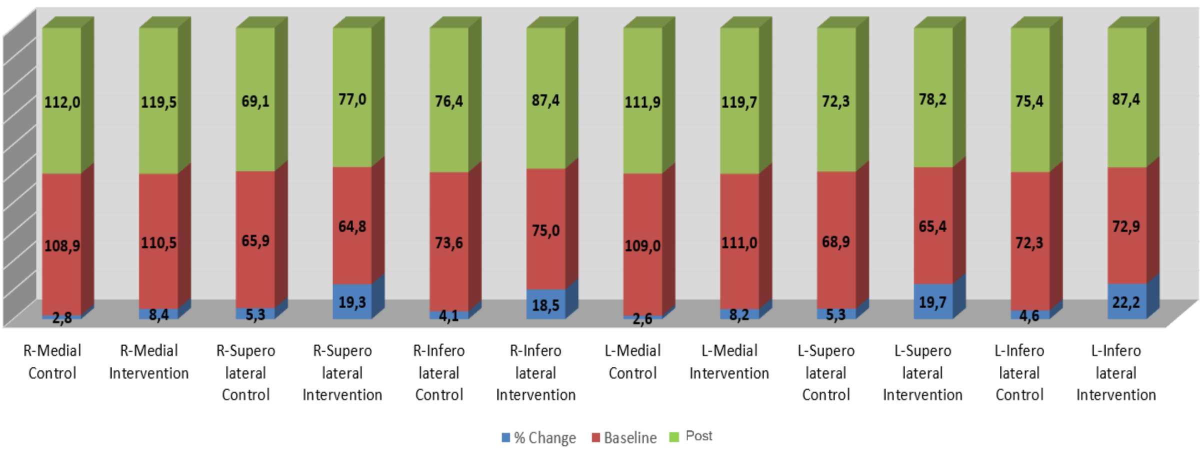

Figure 4.4: Protocol 3: Upper Quarter Y-Balance Test (UQYBT) *The* ***UQYBT*** *includes 6 planes that were tested – Left and right arm reach: Medial, Superolateral and Inferolateral. The test is measured in centimetres.*

Table 4.8 and Figure 4.5 present the rest of the stability tests in Protocol 3 (i.e., the Scapular Retraction test, the Push-up Plus Test, and the CKCUEST). The intervention group exhibited statistically significant improvements ($p < 0.001$) in the Scapular Retraction Test (mean absolute change: 17.65 seconds vs 3.19 seconds for the controls) and the Push-up Plus Test (mean absolute change: 9.00 repetitions vs 3.74 repetitions for the controls). The CKCUEST also showed a significant improvement ($p < 0.001$) in the intervention group (mean absolute change: 2.91 repetitions), while the control group showed a non-significant change (-0.22 repetitions; $p = 0.371$).

Table 4.8: Protocol 3: u/18 and u/19 Shoulder stability tests

	Control	**Intervention**	**Control**	**Intervention**	**Control**	**Intervention**
	Scapular Retraction (sec)	**Scapular Retraction (sec)**	**Push-up Plus (reps)**	**Push-up Plus (reps)**	**CKCUEST (reps)**	**CKCUEST (reps)**
Baseline test	17.27±10.59	22.07±12.83	17.04±5.70	16.48±8.50	15.46±1.98	15.49±1.91
Follow-up test	20.46±11.53	39.72±15.04	20.78±5.89	25.48±6.83	15.24±1.76	18.40±2.25
Mean absolute change	3.19	17.65	3.74	9.00	-0.22	2.91
p-value	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.371	< 0.001*

*Data presented as mean±SD; *p < 0.05 are statistically significant; Abbreviations: CKCUEST: Closed Kinetic Chain Upper Extremity Stability Test*

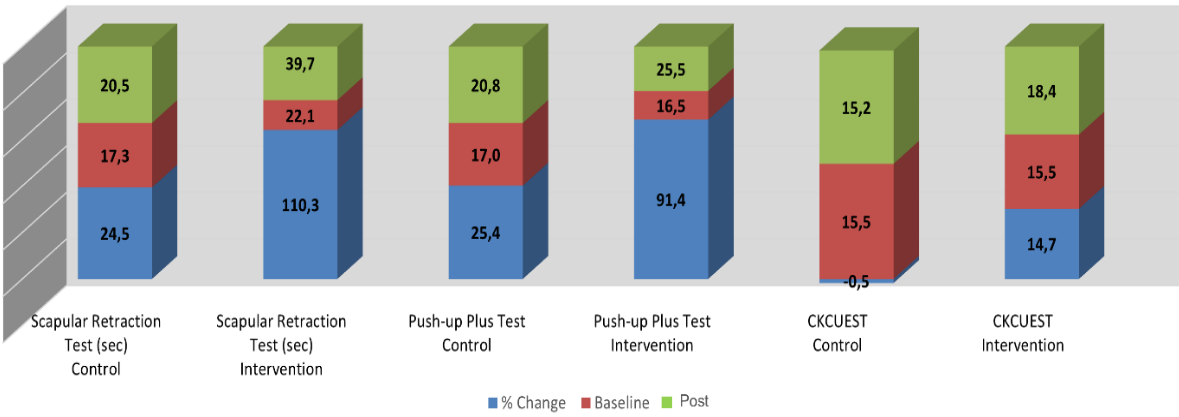

Figure 4.5: Protocol 3: Shoulder stability tests. *Tests include the Scapular Retraction test measured in seconds, the Push-up Plus test measured in repetitions completed, and the Upper Extremity Shoulder Stabilisation Test (CKCUEST) measured in repetitions completed.*

Table 4.9 and Figure 4.6 display the shoulder strength tests for Protocol 3, namely the Isometric Pull-ups test, the 60% Body Weight Shoulder Press Test, and the 1-minute Push-ups Test. The combined training protocol resulted in significant improvements ($p < 0.001$) in all strength measures for the intervention group compared to the control group. In the Isometric Pull-up Test, the intervention group achieved an average increase of 11.13 seconds, while the control group improved by 2.57 seconds, a difference that was statistically significant (p = 0.047). For the Shoulder Press using 60% body weight, the intervention group demonstrated a substantial gain of 6.09 repetitions on average, compared to the control group's improvement of 1.83 repetitions, with a highly significant p-value (< 0.001). Similarly, in the 1-minute Push-ups Test, the intervention group showed a larger increase of 9.30 repetitions on average, while the control group improved by 2.91 repetitions, also with a highly significant p-value (< 0.001). These findings indicate that the combined stability and resistance training protocol (Protocol 3) was effective in enhancing the shoulder strength of the older adolescent rugby players.

Table 4.9: Protocol 3: u/18 and u/19 Shoulder strength tests

	Control	Intervention	Control	Intervention	Control	Intervention
	Isometric Pull-up (sec)	Isometric Pull-up (sec)	1-min Push-ups (reps)	1-min Push-ups (reps)	Shoulder Press (reps)	Shoulder Press (reps)
Baseline test	37.83±15.56	30.07±16.18	46.43±12.63	41.26±16.55	4.83±4.51	6.43±5.00
Follow-up test	40.41±15.70	41.20±20.18	49.35±11.69	50.57±13.02	6.65±5.12	12.52±5.66
Mean absolute change	2.57	11.13	2.91	9.30	1.83	6.09
p-value	< 0.047	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*

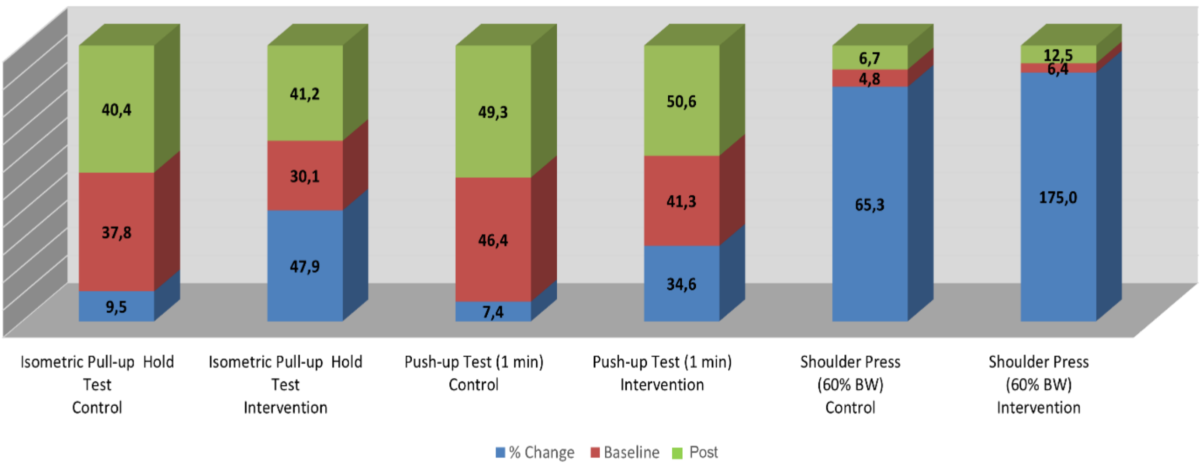

Figure 4.6: Protocol 3: Shoulder strength tests. *The tests include the Isometric Pull-up test measured in seconds, the 1-minute Push-ups test measured in repetitions completed, and the 60% BW Shoulder Press test measured in repetitions.*

CHAPTER 5

5. Discussion

5.1. Introduction

This study aimed to evaluate the effectiveness of stability exercises, resistance training, and a combination of both on shoulder stability and strength in high school rugby players over a six-week pre-season period. Given the high occurrence of shoulder injuries in rugby and the lack of structured, age-specific training protocols, this research provides insight into the effectiveness of a short-duration, pre-season intervention. Baseline measures were reported before all protocols were followed, and the changes were recorded after six weeks. The results indicated significant improvements in the shoulders' general function when it comes to stability and strength.

Few studies have evaluated the relationship between shoulder stability and strength following a short-term protocol, particularly in school rugby players. This is considered a massive research gap since 82.13% of South Africa's rugby population consists of school players (primary school: 50.67%; high school: 31.46%) (46). Although previous studies have explored shoulder function improvements in rugby players (47-49), they targeted professional players aged 18 years and older, leaving a research gap in high school rugby players. Table 5.1 highlights the key findings of our study, indicating that age-specific training protocols can lead to significant improvements in shoulder function.

Table 5.1: Summary table of objectives and findings

Objectives	***Key findings related to objectives***
1. Determine baseline measures of shoulder stability and shoulder strength in school-level rugby players aged 13–19 years.	All initial tests revealed a similar mean result, ensuring equal starting grounds.
2. Compare the changes following six weeks of stability and/or resistance training interventions designed to improve shoulder stability and strength.	There was an increase in shoulder stability in Protocol 1.
	There was an increase in shoulder strength in Protocol 2.
	There was an increase in shoulder stability and strength in Protocol 3.

5.2. Emerging themes from the thesis:

5.2.1. Theme 1: Enhanced shoulder stability through targeted training

The results from Protocol 1 (14–15-year-olds) strongly suggest that a stability-focused training programme is highly effective in improving shoulder stability in younger adolescent rugby players. The significant improvements ($p = 0.001$) observed in the UQYBT, Scapular Retraction Test, and Push-up Plus Test align with the understanding that neuromuscular training, particularly proprioceptive exercises, plays a critical role in developing joint stability during this developmental stage (6).

As demonstrated in the results, the Protocol 1 intervention group showed notable gains in the UQYBT. Schwiertz *et al*. (50) found that the UQYBT is a reliable measure in this age group, with 14–15-year-olds (n=340, aged between 12 and 17 years) showing generally higher achievement compared to the other age groups of 12–13-year-olds and 16–17-year-olds. Although this study did not recruit rugby players only, they did involve athletes only, which means the participants did some form of sports activity. To this end, our findings of substantial improvements in the intervention group's reach distance indicate the efficacy of the implemented stability exercises (e.g., ball push-ups, planks, prone Y's and T's, prone circles). Notably, our senior players from Protocol 3 showed a slightly higher improvement compared to Protocol 1. This suggests that while focused stability work in younger athletes is crucial, older adolescents in a combined programme also benefit significantly in this area. However, the Protocol 1 control group improved more than the Protocol 3 control group following their respective programmes, with results of 1.29cm more on the left-side reach and 1.03cm more on the right-side reach. This can be because the senior rugby players usually focus more on weight and resistance training compared to stability training. While Schwiertz *et al*. (50) provided normative values, our study demonstrates that targeted training can lead to significant positive changes within a short six-week timeframe—Protocol 1 showed more stability improvement compared to strength gains as the former was its main focus.

Furthermore, the intervention group in Protocol 1 demonstrated considerably larger improvements in the rest of their stability tests. These results indicate the significant effectiveness of Protocol 1 ($p = 0.001$). Notably, our results appear better compared to previous studies by Singh *et al*. (51) (n=51 rugby players aged 18-35 years old, following a twelve-week stability protocol) and Ashworth *et al. (52)* (n=18 elite rugby players, with a mean age of 22.4 years old). However, this can be due to the inclusion of shoulder injuries in previous work, which were not included in this study.

The greater improvement in the Protocol 1 intervention group compared to their control group and the observation that they achieved comparable or even slightly larger improvements in some UQYBT measures compared to the Protocol 3 intervention group highlight the importance of early emphasis on fundamental shoulder stability, which may lay a foundation for more complex training later on. This aligns with the understanding that younger adolescents experience rapid growth spurts, which can lead to temporary strength imbalances and reduced coordination, making stability training a crucial foundation (8). These findings are consistent with the recommendations of Roberts *et al.* (13) and Suarez-Garcia *et al.* (14), who also found that stability exercises contribute to enhanced shoulder stability in rugby players. It is essential to consider, however, that individual responses to training can vary, potentially due to factors like prior training history, which were not strictly controlled in this school setting. Nevertheless, the findings strongly support the value of targeted stability training for enhancing shoulder stability in rugby players. While some previous studies on stability showed great results, our study's findings are significant in the context of adolescent athletes without known prior shoulder injuries.

Rogowski *et al.* (47) did an intervention which included 18-year-old male rugby union players (n=86) with healthy shoulders. They determined the baseline shoulder stability of the players by using the UQYBT. All players followed their routine gym programme as set by the rugby union, which included more weight-lifting exercises like shoulder press, bench press, bent-over rows, etc. The players were retested after 4.5 months and showed statistically significant ($p < 0.001$) stability improvements.

In a study done by Suarez-Garcia *et al.* (14), thirty rugby players (n=15 control group, n=15 intervention group) with a mean age of 25.13 years participated in their intervention that only lasted four weeks. The pre-tests included the UQYBT and the CKCUEST. The intervention group followed bilateral exercises that included plyometrics, proprioception and strength exercises. The participants only exercised 15 minutes a day. What sets Suarez-Garcia's study apart from ours is the fact that they only exercised half the time, were older participants and had a 2-week shorter programme. This is thus not directly comparable even though the results also indicated a significant difference between improvement of the study groups ($p < 0.001$). Our study, focusing on a younger demographic and a slightly longer duration, further underscores the potential for rapid stability improvements with targeted exercises, even within the constraints of a school sports programme.

5.2.2. Theme 2: The impact of resistance training on shoulder strength in mid-adolescence

Protocol 2 (16–17-year-olds) demonstrated that resistance training is an effective modality for enhancing shoulder strength in mid-adolescent rugby players. The significant improvements ($p = 0.001$) in the Isometric Pull-up Test, Shoulder Press, and 1-minute Push-ups strongly support the principle of progressive overload for strength development in individuals with a greater degree of musculoskeletal maturity (29).

The results clearly showed a substantial percentage increase in the Shoulder Press for the intervention group compared to the control group. This significant difference highlights the effectiveness of the chosen resistance exercises, which included flat and incline dumbbell presses, resisted push-ups (with elastic or weight), seated and standing dumbbell shoulder presses, bent-over rows (with neutral, over, and reverse barbell grips), upright rows, and battle ropes. These exercises were designed to target various muscle groups involved in shoulder strength and function, with a progression from lower weights (50% of estimated 1RM) to at least 80% by the end of the six weeks. The fact that some participants who initially could not perform a 60% body weight shoulder press managed to complete repetitions post-programme further underscores the impact of this protocol, resulting in a massive 60.8% improvement rate compared to the control group. These results correspond to studies by Salles *et al*. (53) and Hernández-Belmonte *et al*. (54) that followed shoulder protocols for eight to ten weeks and also had great results. Salles *et al.* did a study on general male athletes (n=90) with a mean age of 20 years old, which included weight training only. After the eight weeks, the intervention group who focused on increased weight training improved in strength whereas the control group stayed the same. Hernández-Belmonte *et al*.'s study tested 48 male participants who were used to weight training and saw a 17.5% improvement over the control group after ten weeks. Although these studies prove the effectiveness of the weight training program, it is not directly comparable to high school rugby players.

While the Isometric Pull-up Test showed a lower percentage change in the intervention group, the control group even regressed slightly. This might be attributed to the test's reliance on both strength and endurance, whereas Protocol 2 primarily focused on dynamic strength gains through exercises with repetitions. Compared to Grgic's *et al.* (43) study, which included 16 intervention test-retests of the Isometric Pull-up (n=238 non-sport-specific athletic males aged 18 years and older), the percentage change should be higher than 50% when retesting after following a proper protocol that includes weight training like shoulder press, lat pull-downs, bench press and rows. The relatively smaller improvement in our study's intervention group might suggest that while their strength improved, the specific isometric endurance or stability required for this test was not as directly targeted. Lat pull-downs and pull-ups were also not included in the programme. It's possible that incorporating more isometric holds or stability-focused exercises could yield greater improvements in this specific measure for this age group. Comparing the Isometric Pull-up results of Protocol 2 with Protocol 3, we see a greater improvement in the older group who also engaged in stability exercises, suggesting a potential synergistic effect.

The control group only improved their 1-minute Push-up Test with 3.04 repetitions, and the intervention improved by 6.94 repetitions. Once again, the lower percentage change could be due to focusing on strength only, and doing an exercise for 1 minute without rest requires more endurance (43). Baumgartner *et al.* (55) found that body weight had an influence on participants (n=88 male college students with no specific sport) and improvement came from doing regular bench presses over a period of eight weeks.

The significant strength gains observed in our study after six weeks are noteworthy when compared to findings from studies with longer intervention periods (53, 54). This highlights the potential for a focused pre-season resistance programme to yield meaningful strength improvements even within a limited timeframe, which is practically relevant results for the practical constraints of school rugby seasons. It holds promise for improving shoulder strength in mid-adolescent rugby players, potentially enhancing their performance in activities like tackling and hand-offs. However, as previously mentioned, the lack of integrated stability exercises in Protocol 2 might explain why the Isometric Pull-up improvements were not as pronounced as the dynamic strength gains. A review by Behm *et al.* (56) suggests that adolescent athletes benefit from combined stability and strength training, as is more comprehensively addressed in Protocol 3, and that isolated resistance training may not sufficiently target proprioceptive mechanisms.

5.2.3. Theme 3: Synergistic benefits of combined stability and strength training for older adolescents

The 18–19-year-olds in Protocol 3, following a combined stability and resistance training programme, exhibited balanced and significant improvements ($p = 0.001$) in both shoulder stability and strength. This finding underscores the value of a comprehensive training approach for older adolescent rugby players who require both robust strength for tackling and collisions and dynamic stability to prevent injuries during high-intensity gameplay.

The results showed substantial improvements in UQYBT scores in the intervention group, alongside significant gains in the Scapular Retraction Test and Push-up Plus Test, demonstrating the positive impact of integrating stability exercises (including ball push-ups, planks, prone Y's and T's) within the combined protocol. Similarly, the significant increases in all three strength tests—Isometric Pull-up, Shoulder Press, and 1-minute Push-ups—highlight the continued importance of resistance training (incorporating dumbbell and barbell exercises, resisted push-ups, and battle ropes) in this more physically demanding stage of their rugby careers.

While Burkhead *et al*. (49) and Park *et al.* (50) demonstrated positive effects of stability training on shoulder function, often only in rehabilitative contexts, this study indicates that a combined approach in healthy adolescent athletes can concurrently enhance both stability and strength to a significant degree within a pre-season timeframe. The effectiveness of our six-week combined protocol can unfortunately not be compared with results from longer programme studies due to a significant gap in literature. Nonetheless, our results suggest that a well-structured, time-efficient pre-season programme can be highly beneficial for senior school rugby players, preparing them for the physical demands of the season while potentially mitigating injury risks.

The observation that Protocol 3 yielded the best overall results across both stability and strength measures strongly supports Behm *et al*.'s (56) suggestion that adolescent athletes benefit from a combination of stability and strength exercises to target both strength and proprioceptive mechanisms effectively. This holistic approach ensures that older players develop the necessary strength for the physical demands of rugby while simultaneously enhancing the stability required to protect the shoulder joint during high-impact activities.

The significant improvements observed in Protocol 3, where older adolescent rugby players underwent a combined stability and resistance training programme, are consistent with findings from previous studies that also reported positive outcomes with mixed exercise programmes within a short timeframe (57, 58). These earlier studies, like ours, demonstrate that interventions incorporating both stability and resistance exercises can be effective in enhancing shoulder function without solely focusing on stability training.

Overall, Protocol 3 showed the most balanced improvements in both stability and strength, suggesting that a combined training approach is particularly beneficial for older adolescent rugby players preparing for the higher physical demands of more competitive levels (7).

5.3. Individual and environmental influences on adaptation

Individual inconsistency in response to training highlights the importance of personalised programming. Some of these rugby players may have adapted better to the protocol or even the normal control group programme due to prior strength training experience or natural physical talents. On the same note, some may have struggled more even during the intervention due to physical predisposition or weakness. Excessive fatigue when overtraining and trying to do too much in a session could have limited gains in certain performance markers (59).

Recovery strategies and workload balance likely influenced adaptation rates since only a few of the participants had the discipline to plan their schedules better and the study did not control training loads outside the intervention, which also may have varied between participants and influenced individual responses. The potential impact of delayed-onset of muscle soreness (DOMS) could also have impacted the post-intervention tests.

Another external influence includes the training environment. Although the protocols were standardised, factors including sleep, nutrition, and other physical activities could have contributed to inter-individual result differences. Research discovered that sleep deprivation can potentially impact muscle recovery and strength gains (60), limiting results over the three groups. These external factors should be considered when interpreting the magnitude of the observed changes and when designing future interventions.

5.4. Strengths of the study

The study addressed a critical gap in adolescent school rugby training and shoulder injury prevention by focusing on this specific demographic. Existing literature predominantly focuses on elite athletes or adults. The development of age-specific training guidelines and protocols (Protocol 1 for 14–15-year-olds focusing on stability, Protocol 2 for 16–17-year-olds transitioning to strength, and Protocol 3 for 17–19-year-olds combining strength and stability) is a key strength, as it considers the varying physical and physiological changes during adolescence.

The study implemented a short, time-efficient pre-season programme of six weeks, which addresses the practical constraints faced by school-level athletes with demanding schedules and limited training windows before competitions begin. The protocol was designed for seamless integration into existing training routines. The randomised controlled trial design allowed for a comparison of the effects of different training protocols (stability, resistance, and combined) against a control group, providing a strong basis for inferring causality.

The study had a high adherence rate of 88.75%, indicating that the participants were committed to the protocols, and the findings are likely based on a consistent intervention. Additionally, a 100% response rate for participants who completed the programme ensures a comprehensive analysis.

The study used validated tests to measure shoulder stability (Upper Quarter Y-Balance Test (UQYBT), Scapular Retraction Test, Push-Up Plus Test, Closed Kinetic Chain Upper Extremity Shoulder Stabilisation Test (CKCUEST)) and strength (Isometric Pull-up Test, 1-Minute Push-ups Test, 60% Body Weight Shoulder Press Test), enhancing the reliability and validity of the findings. The document mentions instructions for setup and measurement for accuracy.

The research was conducted in a real-world setting at the school's high-performance centre and supervised by a registered Biokineticist who had an existing relationship with the participants, increasing the ecological validity of the findings for this specific population.

The study explicitly considered ethical considerations, including obtaining ethical clearance, permission from the school, informed consent from parents/guardians and participants (including assent for minors), and outlining data management and confidentiality procedures in line with POPIA.

The findings provide practical implications for rugby coaches and practitioners by offering evidence-based insights into effective training strategies for different age groups of school rugby players.

5.5. Limitations

Although this study provides valuable insights, several limitations should be considered. The inherent challenges of maintaining consistent training adherence in a school setting, coupled with the lack of control over external factors such as individual training habits outside the protocol, nutrition, and sleep, could have influenced the variability in responses. The study's focus on a single high school in a specific region also limits the generalisability of the findings to broader or more diverse rugby populations.

Future research could explore the long-term effects of these age-specific protocols on injury incidence and playing performance. Incorporating detailed anthropometric measurements and tracking training loads more rigorously could provide further insights into individual responses to different training modalities. Additionally, investigating the optimal balance between stability and resistance training within a combined programme for older adolescents would be beneficial. Future studies could also explore the potential benefits of incorporating low-load resistance training into stability programmes for younger athletes to enhance strength development while safeguarding joint integrity. Furthermore, expanding the study to include multiple schools or regions would enhance the generalisability of the findings. Finally, acknowledging and accounting for external factors such as sleep, nutrition, and the overall well-being of the participants would contribute to a more comprehensive understanding of training adaptations.

In conclusion, this study provides evidence for the effectiveness of age-specific shoulder training interventions in high school rugby players. Prioritising stability for younger athletes and adopting a combined approach for older athletes appear to be effective strategies for improving shoulder function in a short pre-season timeframe. These findings have practical implications for coaches and practitioners aiming to enhance performance and reduce injury risk in young rugby players.

CHAPTER 6

6. Conclusion and Recommendations

6.1. Conclusion

This study provides valuable insights into the effects of stability exercises, resistance training, and a combined approach on shoulder stability and strength in high school rugby players. The findings highlight the importance of age-specific training interventions, with controlled stability exercises proving most effective for younger athletes (14–15 years) during their developing stage, and a combined approach for players in their mid-adolescent to senior high school players (16–19 years). The study confirms the role of structured pre-season training in enhancing shoulder function, which can be done in a shorter period of time and potentially reduces injury risk.

By following these protocols and including them in weekly training programmes, coaches and biokineticists can better prepare young athletes for the physical demands of this high-impact sport, ensuring they reach their optimal strength goal in time.

While this study provides numerous effective insights, certain limitations should be acknowledged, including participant commitment due to after-school activities, uncontrolled external factors like academic responsibilities, natural predispositions, nutrition, sleep and self-care routines, excessive fatigue or mental health of the participants. The sample size using a single school also limited the study, and future research should use a broader spectrum of rugby players.

The study also lacked detailed tracking of anthropometric measurements and training loads, which could offer greater clarity on individual training responses in future research. Notably, participants with current shoulder injuries were excluded, presenting an opportunity for future studies to explore the application of these protocols in rehabilitation contexts. Additionally, the potential influence of some control group participants engaging in extra training outside their standard programme might have reduced the observed differences between the intervention and control groups.

Despite these limitations, the study highlights that strength gains were particularly noticeable in the 16–17-year-old group (Protocol 2), reinforcing the efficacy of structured resistance training for this age group. Ultimately, the findings support the implementation of age-appropriate, structured pre-season training programmes concentrated on enhancing shoulder stability and strength to better prepare young rugby players for the demands of the sport and potentially mitigate injury risks.

In conclusion, the results support the need for well-structured, progressive training strategies, aligning with adolescent athletes’ developmental stages in a set time-frame. By integrating stability and strength components appropriately, rugby players can improve overall shoulder function, ultimately contributing to enhanced performance and preventing injury in the sport.

6.2. Recommendation for future research

After evaluating the results, a few notes can be taken away to improve future research regarding this study and the effectiveness thereof.

Future studies could explore the long-term effects of these training protocols on shoulder stability and strength, as well as their impact on performance in competitive rugby. Since previous shoulder injuries were excluded, future studies can include these participants in order to examine the recovery rate and see if the shoulder can obtain average strength compared to the age group. Detailed anthropometric assessments should be done regularly.

Research should also look to assess whether extending the duration of stability training or incorporating low-load resistance training in the younger group, could enhance strength while maintaining joint integrity.

External factors should be taken into consideration, especially if the participants already have a tight schedule that overloads their muscles. Their well-being should be considered since a low mental state will influence training performance.

Future research should aim to expand the sample size by including multi-school or regional comparisons to assess whether similar training adaptations occur in different competitive environments.

Finally, key highlights include that stability exercises were most effective for younger players (14–15 years), while strength and stability training will have greater benefits for older athletes (16–19 years). Anthropometric factors, including skeletal maturity, muscle mass, and neuromuscular coordination, influenced training responses, which emphasised the need for personalised age-appropriate training strategies. Strength gains were most notable in the 16–17-year-old group, underscoring the importance of structured resistance training once athletes reach sufficient musculoskeletal maturity. Commitment to training, academic demands, and other lifestyle factors impacted performance outcomes, suggesting the need for better integration of training into athletes' schedules. Lastly, the findings reinforce the importance of structured pre-season training programmes in a limited time frame to enhance shoulder stability and strength, ultimately reducing injury risk in young rugby players.

7. References

1. Gray J. Phases of Rehabilitation after Injury: An Evidence-Based Literature Review. BokSmart. 2009;1:1-32.
2. Wilk KE, Obma P, Simpson CD, Cain EL, Dugas J, Andrews JR. Shoulder injuries in the overhead athlete. Journal of orthopaedic & sports physical therapy. 2009;39(2):38-54.
3. Pollock AM, White AJ, Kirkwood G. Evidence in support of the call to ban the tackle and harmful contact in school rugby: a response to World Rugby. British journal of sports medicine. 2017;51(15):1113-7.
4. Papalia R, Tecame A, Torre G, Narbona P, Maffulli N, Denaro V. Rugby and shoulder trauma: A systematic review. Translational medicine@ UniSa. 2014;12:5.
5. Leahy TM, Kenny IC, Campbell MJ, Warrington GD, Cahalan R, Harrison AJ, et al. Epidemiology of shoulder injuries in schoolboy rugby union in Ireland. Orthopaedic journal of sports medicine. 2021;9(8):23259671211023431.
6. Huxel Bliven KC, Anderson BE. Core stability training for injury prevention. Sports health. 2013;5(6):514-22.
7. Wilk KE, Ellenbecker TS. Rehabilitation of the Overhead. Elbow Ulnar Collateral Ligament Injury: A Guide to Diagnosis and Treatment. 2021:327.
8. Baxter-Jones AD. Physical growth and development in young athletes: Factors of influence and consequence. Kinesiology Review. 2019;8(3):211-9.
9. Gabbett TJ, Jenkins DG. Relationship between training load and injury in professional rugby league players. Journal of Science and Medicine in Sport. 2011;14(3):204-9.
10. Gabbett T, Kelly J, Pezet T. Relationship between physical fitness and playing ability in rugby league players. The Journal of Strength & Conditioning Research. 2007;21(4):1126-33.
11. Morgan R, Herrington L. The effect of tackling on shoulder joint positioning sense in semi-professional rugby players. Physical Therapy in Sport. 2014;15(3):176-80.
12. Asker M, Brooke HL, Waldén M, Tranaeus U, Johansson F, Skillgate E, et al. Risk factors for, and prevention of, shoulder injuries in overhead sports: a systematic review with best-evidence synthesis. British journal of sports medicine. 2018;52(20):1312-9.
13. Roberts SP, Trewartha G, England M, Shaddick G, Stokes KA. Epidemiology of time-loss injuries in English community-level rugby union. BMJ open. 2013;3(11):e003998.
14. Suárez García M, López Mardomingo P, Nah-Mohamed M, Cuesta Barriuso R. Improved shoulder stability through plyometric, proprioceptive and strength exercises in rugby players. A randomized clinical trial. 2021.
15. Petré H, Löfving P, Psilander N. The effect of two different concurrent training programs on strength and power gains in highly-trained individuals. Journal of sports science & medicine. 2018;17(2):167.
16. Keogh JW, Hume PA, Pearson SN, Mellow P. Anthropometric dimensions of male powerlifters of varying body mass. Journal of Sports Sciences. 2007;25(12):1365-76.

17. Asker M, Whiteley R. Rehabilitation and Return to Sports After Shoulder Injuries. Orthopaedic Sports Medicine: An Encyclopedic Review of Diagnosis, Prevention, and Management: Springer; 2024. p. 1-23.

18. Edwards AM, Dutton-Challis L, Cottrell D, Guy JH, Hettinga FJ. Impact of active and passive social facilitation on self-paced endurance and sprint exercise: encouragement augments performance and motivation to exercise. BMJ open sport & exercise medicine. 2018;4(1):e000368.

19. Häkkinen K, Newton RU, Gordon SE, McCormick M, Volek JS, Nindl BC, et al. Changes in muscle morphology, electromyographic activity, and force production characteristics during progressive strength training in young and older men. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences. 1998;53(6):B415-B23.

20. Folland JP, Williams AG. Morphological and neurological contributions to increased strength. Sports medicine. 2007;37:145-68.

21. Staron R, Karapondo D, Kraemer W, Fry A, Gordon S, Falkel JE, et al. Skeletal muscle adaptations during early phase of heavy-resistance training in men and women. Journal of applied physiology. 1994;76(3):1247-55.

22. Seynnes OR, de Boer M, Narici MV. Early skeletal muscle hypertrophy and architectural changes in response to high-intensity resistance training. Journal of applied physiology. 2007;102(1):368-73.

23. DeFreitas JM, Beck TW, Stock MS, Dillon MA, Kasishke PR. An examination of the time course of training-induced skeletal muscle hypertrophy. European journal of applied physiology. 2011;111:2785-90.

24. Brook MS, Wilkinson DJ, Mitchell WK, Lund JN, Szewczyk NJ, Greenhaff PL, et al. Skeletal muscle hypertrophy adaptations predominate in the early stages of resistance exercise training, matching deuterium oxide-derived measures of muscle protein synthesis and mechanistic target of rapamycin complex 1 signaling. The FASEB Journal. 2015;29(11):4485-96.

25. Damas F, Phillips SM, Libardi CA, Vechin FC, Lixandrão ME, Jannig PR, et al. Resistance training-induced changes in integrated myofibrillar protein synthesis are related to hypertrophy only after attenuation of muscle damage. The Journal of physiology. 2016;594(18):5209-22.

26. Parry GN, Williams S, McKay CD, Johnson DJ, Bergeron MF, Cumming SP. Associations between growth, maturation and injury in youth athletes engaged in elite pathways: a scoping review. British Journal of Sports Medicine. 2024;58(17):1001-10.

27. Furrer R, Hawley JA, Handschin C. The molecular athlete: exercise physiology from mechanisms to medals. Physiological reviews. 2023.

28. Sclafani MP, Davis CC. Return to play progression for rugby following injury to the lower extremity: a clinical commentary and review of the literature. International journal of sports physical therapy. 2016;11(2):302.

29. Faigenbaum AD, Myer GD. Resistance training among young athletes: safety, efficacy and injury prevention effects. British journal of sports medicine. 2010;44(1):56-63.

30. Lloyd RS, Oliver JL. The youth physical development model: A new approach to long-term athletic development. Strength & Conditioning Journal. 2012;34(3):61-72.

31. Talukdar K. Sports Fit: Bridging the gap between research and practice: Notion Press; 2018.

32. Hislop MD, Stokes KA, Williams S, McKay CD, England M, Kemp SP, et al. The efficacy of a movement control exercise programme to reduce injuries in youth rugby: a cluster randomised controlled trial. BMJ Open Sport Exerc Med. 2016;2(1):e000043.

33. Hislop MD, Stokes KA, Williams S, McKay CD, England ME, Kemp SPT, et al. Reducing musculoskeletal injury and concussion risk in schoolboy rugby players with a pre-activity movement control exercise programme: a cluster randomised controlled trial. Br J Sports Med. 2017;51(15):1140-6.

34. Salles JI, Velasques B, Cossich V, Nicoliche E, Ribeiro P, Amaral MV, et al. Strength training and shoulder proprioception. J Athl Train. 2015;50(3):277-80.

35. Attwood MJ, Roberts SP, Trewartha G, England ME, Stokes KA. Efficacy of a movement control injury prevention programme in adult men's community rugby union: a cluster randomised controlled trial. Br J Sports Med. 2018;52(6):368-74.

36. Barden C, Hancock MV, Stokes KA, Roberts SP, McKay CD. Effectiveness of the Activate injury prevention exercise programme to prevent injury in schoolboy rugby union. British Journal of Sports Medicine. 2022;56(14):812-7.

37. West SW, Shill IJ, Bailey S, Syrydiuk RA, Hayden KA, Palmer D, et al. Injury Rates, Mechanisms, Risk Factors and Prevention Strategies in Youth Rugby Union: What's All the Ruck-Us About? A Systematic Review and Meta-analysis. Sports Medicine. 2023;53(7):1375-93.

38. Schwank A, Blazey P, Asker M, Møller M, Hägglund M, Gard S, et al. 2022 Bern Consensus Statement on Shoulder Injury Prevention, Rehabilitation, and Return to Sport for Athletes at All Participation Levels. J Orthop Sports Phys Ther. 2022;52(1):11-28.

39. Westrick RB, Miller JM, Carow SD, Gerber JP. Exploration of the y-balance test for assessment of upper quarter closed kinetic chain performance. International journal of sports physical therapy. 2012;7(2):139.

40. Khazzam M, Gates ST, Tisano BK, Kukowski N. Diagnostic accuracy of the scapular retraction test in assessing the status of the rotator cuff. Orthopaedic journal of sports medicine. 2018;6(10):2325967118799308.

41. Yoo W-g. Effect of the push-up plus guide and resistance device (PPGRD) on the serratus anterior during push-up plus. Journal of Physical Therapy Science. 2016;28(11):3241-2.

42. Tucci HT, Martins J, Sposito GdC, Camarini PMF, De Oliveira AS. Closed Kinetic Chain Upper Extremity Stability test (CKCUES test): a reliability study in persons with and without shoulder impingement syndrome. BMC musculoskeletal disorders. 2014;15:1-9.

43. Grgic J, Scapec B, Mikulic P, Pedisic Z. Test-retest reliability of isometric mid-thigh pull maximum strength assessment: A systematic review. Biology of sport. 2022;39(2):407-14.

44. Diehl C, Johnson Q, Moses J, Hicks J, Lindsay K, Dawes J, et al., editors. Interrater reliability of assessing the 1-minute push-up test. International Journal of Exercise Science: Conference Proceedings; 2019.

45. Dicus JR, Holmstrup ME, T SHULER K, T RICE T, D RAYBUCK S, Siddons CA. Stability of resistance training implement alters EMG activity during the overhead press. International Journal of Exercise Science. 2018;11(1):708.

46. Lambert MI. Long-term player development in rugby-how are we doing in South Africa? South African Journal of Sports Medicine. 2010;22(3):67-8.
47. Rogowski I, Degot M, Juré D, Hager J-P, Neyton L, Blache Y. Shoulder functional status in rugby union players with and without history of shoulder problems. Physical Therapy in Sport. 2020;45:71-5.
48. Hamlin MJ, Deuchrass R, Elliot C, Raj T, Promkeaw D, Phonthee S. Effect of a 6-week exercise intervention for improved neck muscle strength in amateur male rugby union players. 2020.
49. Sewry N, Verhagen E, Lambert M, Van Mechelen W, Brown J. Evaluation of the effectiveness and implementation of the BokSmart Safe Six injury prevention programme: a study protocol. Injury prevention. 2017;23(6):428-.
50. Schwiertz G, Bauer J, Muehlbauer T. Upper Quarter Y Balance test performance: Normative values for healthy youth aged 10 to 17 years. PLoS One. 2021;16(6):e0253144.
51. Singh VR, Stokes K, Mckay CD. Feasibility and acceptability of a new shoulder-specific warm-up programme to prevent injuries in community youth rugby union as compared to the FIFA 11+. International Journal of Sports Science & Coaching. 2024;19(3):1093-104.
52. Ashworth B, Hogben P, Singh N, Tulloch L, Cohen DD. The Athletic Shoulder (ASH) test: reliability of a novel upper body isometric strength test in elite rugby players. BMJ Open Sport & Exercise Medicine. 2018;4(1):e000365.
53. Salles JI, Velasques B, Cossich V, Nicoliche E, Ribeiro P, Amaral MV, et al. Strength training and shoulder proprioception. Journal of athletic training. 2015;50(3):277-80.
54. Hernández-Belmonte A, Martínez-Cava A, Morán-Navarro R, Courel-Ibáñez J, Pallarés J. A comprehensive analysis of the velocity-based method in the shoulder press exercise: stability of the load-velocity relationship and sticking region parameters. Biology of Sport. 2021;38(2):235-43.
55. Baumgartner TA, Oh S, Chung H, Hales D. Objectivity, reliability, and validity for a revised push-up test protocol. Measurement in Physical Education and Exercise Science. 2002;6(4):225-42.
56. Behm DG, Drinkwater EJ, Willardson JM, Cowley PM. The use of instability to train the core musculature. Applied physiology, nutrition, and metabolism. 2010;35(1):91-108.
57. Shaffer SW, Teyhen DS, Lorenson CL, Warren RL, Koreerat CM, Straseske CA, et al. Y-balance test: a reliability study involving multiple raters. Military medicine. 2013;178(11):1264-70.
58. Foldager FN, Aslerin S, BÆ S, Tønning LU, Mechlenburg I. Interrater, test-retest reliability of the Y balance test: A reliability study including 51 healthy participants. International journal of exercise science. 2023;16(4):182.
59. Impellizzeri FM, Marcora SM, Coutts AJ. Internal and external training load: 15 years on. Int J Sports Physiol Perform. 2019;14(2):270-3.
60. Simpson N, Gibbs E, Matheson G. Optimizing sleep to maximize performance: implications and recommendations for elite athletes. Scandinavian journal of medicine & science in sports. 2017;27(3):266-74.

8. Appendices

8.1. Appendix 1: Protocols and Exercises

Protocol 1: Stability Training						
	Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**
Exercises	Ball push-ups, ball planks, side plank (elbow / straight arm), plank with alternating arm lifts, prone Y's and T's, prone circles, elbow to straight arm plank, isometric push-ups					
Time (s)	30	35	40	45	50	60
Sets	2	2	2	2	2	2
Protocol 2: Resistance						
	Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**
Exercises	Dumbbell bench press (flat / incline), resisted push-ups (weight / elastic), dumbbell shoulder press (seated / standing), bent-over rows (dumbbell neutral grip / barbell over grip / barbell reverse grip), upright rows, battle ropes (single arm / alternating / bilateral)					
Sets	3	3	4	4	5	5
Weight Repetitions	8	8	10	10	12	12
Battle Ropes	25	30	35	40	45	50
Weight (%BW to 1RM)	50	60	65	70	75	80
Protocol 3: Stability and Resistance						
	Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**
Exercises	Ball push-ups, ball planks, side plank (elbow / straight arm), plank with alternating arm lifts, prone Y's and T's, prone circles, elbow to straight arm plank, isometric push-ups					
Time (s)	30	35	40	45	50	60
Sets	3	3	4	4	5	5
Exercises	Dumbbell bench press (flat / incline), resisted push-ups (weight / elastic), dumbbell shoulder press (seated / standing), bent-over rows (dumbbell neutral grip / barbell over grip / barbell reverse grip), upright rows, battle ropes (single arm / alternating / bilateral)					
Sets	3	3	4	4	5	5
Weight Repetitions	8	8	10	10	12	12
Battle Ropes	25	30	35	40	45	50
Weight (%BW to 1RM)	50	60	65	70	75	80

<table>
<tr><th colspan="4">Protocol 1 & 3 Exercises for Stability</th></tr>
<tr><th colspan="2">Ball Push-ups</th><th colspan="2">Ball Planks</th></tr>
<tr><td></td><td></td><td colspan="2"></td></tr>
<tr><th colspan="2">Side Planks</th><th colspan="2">Plank with alternating arm lift</th></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><th colspan="2">Prone Y’s</th><th colspan="2">Prone T’s</th></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><th colspan="3">Prone Circles</th><th>Isometric Push-up</th></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><th colspan="4">Elbow to straight arm Plank (Commando’s)</th></tr>
<tr><td></td><td></td><td></td><td></td></tr>
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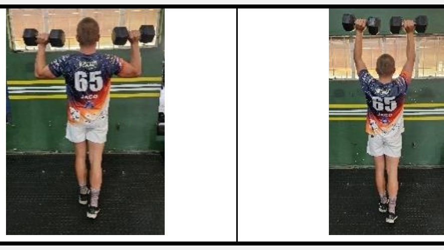
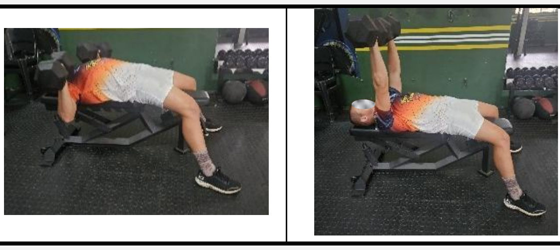
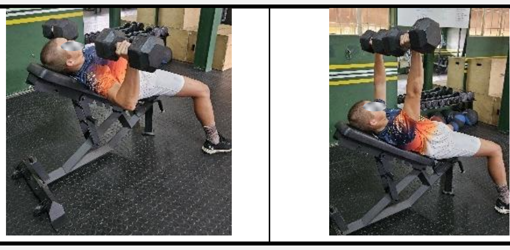
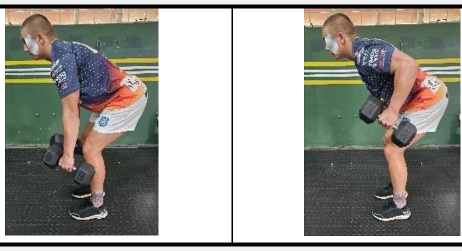
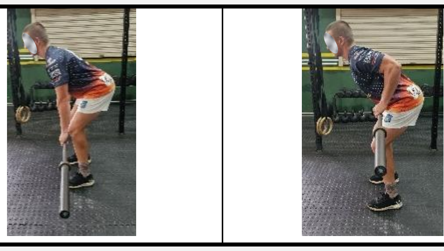
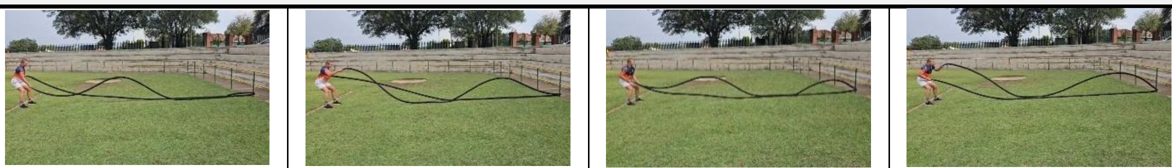
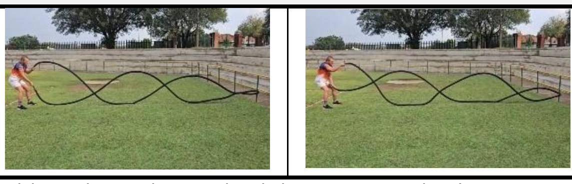
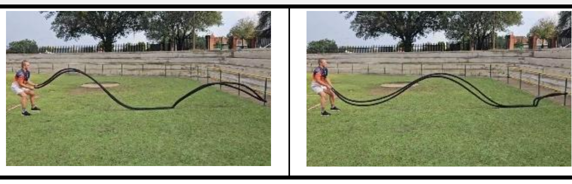
Participants have volunteered and given consent to photo’s

Protocol 2 & 3 Exercises for Resistance	
Seated Dumbbell Shoulder press	**Standing Dumbbell Shoulder Press**
	
Flat Dumbbell Bench Press	**Incline Dumbbell Bench Press**
	
Bent-over Dumbbell Rows	**Bent-Over Barbell Rows Over grip**
	
Bent-over Barbell Rows Reverse grip	**Upright Barbell Rows**
	
Resisted Elastic Push-ups	**Resisted Weight Push-ups**
	
Battle Ropes One Arm	
	
Battle Ropes Alternating	**Battle Ropes Bilateral**
	

Participants have volunteered and given consent to photo's

8.2. Appendix 2: Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

EC-250208-004 Mrs Limeri Smal

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M240822

NAME: (**Principal Investigator**)	Mrs Limeri Smal
DEGREE:	MSc (Med) Biokinetics
DEPARTMENT:	Exercise Science and Sport Medicine
STUDY SITE(S):	High-Performance Centre of Hoër Volkskool Heidelberg
TITLE:	The Effectiveness of Stability Exercises and Resistance Training in Improving Shoulder Stability and Shoulder Strength in School Rugby Players
DATE CONSIDERED:	30/08/2024
DECISION:	Approved unconditionally
CONDITIONS:	
NOTE:	Original Application Number MED23-10-274. Subsequent Online Application Number M241211-J-0001.
SUPERVISOR:	Prof P Gradidge, Mrs N Neophytou and Mrs M Phaswana
APPROVED BY:	Professor P. Ruff, Chairperson, HREC (Medical)

DATE OF APPROVAL: 11/12/2024 **EXPIRY DATE:** 10/12/2029

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATOR(S)

I/we fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report** in the month date of convened meeting each year until study is closed. Failure to submit annual report will result in ethics clearance certificate suspension. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. Unreported changes to the application may invalidate the clearance given by the HREC (Medical). Email a signed copy of ethics clearance certificate to HREC-Medical.ResearchOffice@wits.ac.za.

LSmal

Principal Investigator Signature

12 / 01 / 2025

Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

8.3. Appendix 3: Approval Letter from School

HOËR VOLKSKOOL HEIDELBERG

Posbus 215, Heidelberg, Gauteng, 1438

Tel: (016) 341 3165/6 Faks: (016) 341 3987 E-pos: hvhadmin@lantic.net

22 September 2023

Good day Mrs. L. Smal

It is with great pleasure that I can inform you that your request to conduct your study, titled "***The Effectiveness of Stability Exercises and Resistance Training in Improving Shoulder Stability and Shoulder Strength in School Rugby Players***" to complete your MSc Med in Biokinetics, is approved by Hoër Volkskool Heidelberg and its SGB.

We will support you as far as possible and wish you the best of luck. We look forward to hopefully seeing positive and beneficial results in all of our rugby players and trust everyone will be treated well with safety first in mind.

We also trust that all the correct procedures will be followed.

Regards

J.J. BOTHA
(PRINCIPAL)

8.4. Appendix 4: Information Sheet

Good day

My name is Limeri Smal, a Masters student at the University of the Witwatersrand. My supervisors are Professor Philippe Gradidge, Ms Natalia Neophytou, and Ms Merling Phaswana, who are employed at the University of the Witwatersrand Centre for Exercise Science and Sports Medicine. I am conducting a study about shoulder strength and stability, titled **"The Effectiveness of Stability Exercises and Resistance Training in Improving Shoulder Stability and Shoulder Strength in School Rugby Players."**

I am inviting your child to participate in a six-week school-level rugby exercise protocol that will take place during their scheduled conditioning sessions at Hoër Volkskool Heidelberg's High-Performance Centre / Limeri Smal Biokineticist, which is located under the main pavilion next to the A-rugby field.

With your, as well as your child's consent, I would like to conduct strength and stability tests (1-minute Push-ups, Pull-up Test, Shoulder Stability Y-Test, etc.), which after they will follow a six-week protocol to strengthen their shoulders, and then re-test after the 6 weeks to compare and see if there are any changes.

During the research, I will need their personal information, including age, height, and weight. They would also need to report any chronic medication and injuries. All information will be treated strictly confidential and anonymous. When results are shared, no names or any form of identification will be named. With your, as well as your child's consent, other researchers may use the data collected from this study, but no personal information will be passed on.

This study is completely voluntary. Your child may stop being in the study at any time. They do not have to do anything that they do not want to do. They will not be treated differently or be negatively impacted if they choose not to participate. Taking part in this study will not cost anything. No one will be paid to participate.

The risk of this study will be minor to none since the exercises may in general strengthen the participants and may only cause discomfort due to the intensity of the sessions. If the participant is too uncomfortable, they may stop at any time. The coaches will be supervising to ensure commitment and attendance, while the Biokineticist will ensure that all exercises are followed and done correctly. All aged-appropriate players will be able to join the testing if they are part of the rugby group that trains daily. All participants will do stretches afterward to minimise discomfort.

Potential Risks	Precautions
Injuries in sessions	All weights will be monitored to ensure no participants lift a heavier weight than prescribed.
Working with private, personal information	All results will be kept in a private office where only the Biokineticist will have access to the data. No personal information about the participants that does not pertain to the study will be shared with others.

The study may be beneficial because the participants will be doing shoulder exercises that may strengthen their shoulders and prevent injuries.

The research report and results will be available on the University library. A summary of this report can be sent to you on request.

The research study has received ethical clearance from the University of the Witwatersrand MED23-10-274, certificate number M240822.

If you have any questions regarding this study during or afterward, please do not hesitate to contact me or my supervisors. If you have any concerns or complaints about the ethical procedures of this research study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za.

Yours sincerely,

Limeri

Researcher:

Limeri Smal, 1723900@students.wits.ac.za, 082 050 9109

Supervisors:

Dr. Merling Phaswana, merling.phaswana@wits.ac.za, 011 717 3231

Prof. Philippe Gradidge, philippe.gradidge@wits.ac.za, 011 717 3363

Dr. Natalia Neophytou, natalia.neophytou@wits.ac.za, 011 717 3368

8.5. Appendix 5: Parent / Guardian Consent Form

WITS UNIVERSITY

Consent Form – Parent / Guardian

Project Title: The Effectiveness of Stability Exercises and Resistance Training in Improving Shoulder Stability and Shoulder Strength in School Rugby Players

I, ____ consent to allow my child,

____ to participate in this research study.

<u>I agree to the following (Please circle the relevant option):</u>

The study was explained to me and I understand what it is about.	**YES**	**NO**
I understand that it is completely voluntary and my child can stop at any given time.	**YES**	**NO**
I agree that all personal information about my child may be used.	**YES**	**NO**

I agree that my child's information will be completely anonymous and will not be shared with any other researcher.	**YES**	**NO**
I agree that other researchers may use my child's information (depending on their own ethics clearance being obtained) but my child's name and any other personal information will remain anonymous.	**YES**	**NO**
I understand that I may ask questions at any time.	**YES**	**NO**

Name of parent or guardian : ____

Date : ____

Signature or mark of parent : ____

Name of Researcher : ____

Signature : ____

Date : ____

8.6. Appendix 6: Participant Consent Form

WITS UNIVERSITY

Consent Form – Participant 18+

Project Title: The Effectiveness of Stability Exercises and Resistance Training in Improving Shoulder Stability and Shoulder Strength in School Rugby Players

I, ______________________________________ agree to participate in this research study.

<u>I agree to the following (Please circle the relevant option):</u>

The study was explained to me and I understand what it is about.	**YES**	**NO**
I understand that it is completely voluntary and I can stop at any given time.	**YES**	**NO**
I agree that all my personal information may be used.	**YES**	**NO**

I agree that my information will be completely anonymous and will not be shared with any other researcher.	**YES**	**NO**
I agree that other researchers may use my information (depending on their own ethics clearance being obtained) but my name and any other personal information will remain anonymous.	**YES**	**NO**
I understand that I may ask questions at any time.	**YES**	**NO**

Name of participant : ____

Date : ____

Signature : ____

Name of Researcher :

____

Signature : ____

Date : ____

8.7. Appendix 7: Minor Participant Assent Form

WITS UNIVERSITY

Assent Form – Minor Participant

Project Title: The Effectiveness of Stability Exercises and Resistance Training in Improving Shoulder Stability and Shoulder Strength in School Rugby Players

I, ______________________________________ agree to participate in this research study.

<u>I agree to the following (Please circle the relevant option):</u>

The study was explained to me and I understand what it is about.	**YES**	**NO**
I understand that it is completely voluntary and I can stop at any given time.	**YES**	**NO**
I agree that all my personal information may be used.	**YES**	**NO**

I agree that my information will be completely anonymous and will not be shared with any other researcher.	**YES**	**NO**
I agree that other researchers may use my information (depending on their own ethics clearance being obtained) but my name and any other personal information will remain anonymous.	**YES**	**NO**
I understand that I may ask questions at any time.	**YES**	**NO**

Name of participant : ______________________________

Date : ______________________________

Signature : ______________________________

Name of Researcher :

____

Signature : ______________________________

Date : ______________________________

8.8. Appendix 8: Data Sheets

Protocol 1: Control Group = RED; Intervention Group = GREEN

Participant		Rugby Position	Height	Weight	Y-Balance Test																		Scapular Retraction Test (sec)	Scapular Retraction Test (sec)
					L-Side	L-Side	% Change	L-Top	L-Top	% Change	L-Bottom	L-Bottom	% Change	R-Side	R-Side	% Change	R-Top	R-Top	% Change	R-Bottom	R-Bottom	% Change		
P1 - 01	0	F	174,00	78,60	97,00	98,00	1,03	42,00	44,00	4,76	54,00	54,00	0,00	87,00	92,00	5,75	64,00	68,00	6,25	46,00	48,00	4,35	5,17	6,18
P1 - 03	0	F	175,00	80,00	97,00	101,00	4,12	48,00	51,00	6,25	63,00	65,00	3,17	101,00	105,00	3,96	65,00	66,00	1,54	44,00	51,00	15,91	4,63	4,25
P1 - 05	0	F	174,00	66,50	100,00	103,00	3,00	68,00	72,00	5,88	58,00	61,00	5,17	95,00	100,00	5,26	62,00	68,00	9,68	63,00	69,00	9,52	2,71	3,01
P1 - 07	0	B	159,00	47,00	101,00	102,00	0,99	44,00	48,00	9,09	50,00	57,00	14,00	96,00	102,00	6,25	48,00	52,00	8,33	49,00	56,00	14,29	5,42	6,89
P1 - 09	0	F	159,00	46,00	111,00	119,00	7,21	49,00	52,00	6,12	51,00	58,00	13,73	105,00	110,00	4,76	62,00	69,00	11,29	51,00	54,00	5,88	2,63	2,89
P1 - 11	0	B	166,00	55,00	124,00	125,00	0,81	61,00	68,00	11,48	65,00	70,00	7,69	114,00	116,00	1,75	66,00	72,00	9,09	67,00	74,00	10,45	4,51	6,12
P1 - 13	0	B	171,00	57,00	108,00	111,00	2,78	52,00	58,00	11,54	59,00	62,00	5,08	113,00	120,00	6,19	72,00	79,00	9,72	64,00	72,00	12,50	4,98	6,25
P1 - 15	0	B	167,00	65,60	117,00	120,00	2,56	73,00	79,00	8,22	62,00	64,00	3,23	114,00	118,00	3,51	73,00	78,00	6,85	65,00	66,00	1,54	1,62	4,25
P1 - 17	0	F	168,00	71,00	102,00	108,00	5,88	38,00	51,00	34,21	57,00	68,00	19,30	109,00	110,00	0,92	39,00	48,00	23,08	52,00	64,00	23,08	2,78	3,12
P1 - 19	0	B	162,00	46,00	118,00	114,00	-3,39	75,00	78,00	4,00	71,00	74,00	4,23	117,00	120,00	2,56	93,00	95,00	2,15	67,00	70,00	4,48	3,38	4,51
P1 - 21	0	F	165,00	67,00	118,00	110,00	-6,78	51,00	56,00	9,80	67,00	67,00	0,00	116,00	115,00	-0,86	70,00	72,00	2,86	63,00	66,00	4,76	3,51	4,23
P1 - 23	0	F	171,00	57,90	109,00	110,00	0,92	75,00	76,00	1,33	94,00	92,00	-2,13	113,00	114,00	0,88	97,00	95,00	-2,06	79,00	81,00	2,53	2,84	4,26
P1 - 25	0	B	150,00	44,00	105,00	109,00	3,81	59,00	64,00	8,47	63,00	66,00	4,76	99,00	104,00	5,05	55,00	58,00	5,45	54,00	59,00	9,26	4,73	4,12
P1 - 27	0	F	150,00	54,00	104,00	108,00	3,85	66,00	68,00	3,03	72,00	74,00	2,78	107,00	109,00	1,87	66,00	69,00	4,55	53,00	61,00	15,09	2,28	7,26
P1 - 29	0	F	172,00	50,00	109,00	114,00	4,59	81,00	84,00	3,70	82,00	88,00	7,32	108,00	107,00	-0,93	84,00	86,00	2,38	85,00	88,00	3,53	3,28	4,32
P1 - 31	0	B	168,00	56,70	87,00	92,00	5,75	71,00	72,00	1,41	62,00	63,00	1,61	82,00	90,00	9,76	68,00	71,00	4,41	62,00	62,00	0,00	5,83	8,61
P1 - 33	0	F	182,00	91,00	95,00	99,00	4,21	64,00	65,00	1,56	72,00	74,00	2,78	99,00	100,00	1,01	65,00	66,00	1,54	72,00	76,00	5,56	1,48	3,02
P1 - 35	0	F	173,00	115,00	78,00	81,00	3,85	43,00	49,00	13,95	48,00	52,00	8,33	79,00	84,00	6,33	44,00	51,00	15,91	49,00	52,00	6,12	3,47	3,56
P1 - 37	0	F	164,00	85,00	111,00	112,00	0,90	56,00	62,00	10,71	76,00	84,00	10,53	105,00	110,00	4,76	61,00	68,00	11,48	69,00	72,00	4,35	21,22	24,87
P1 - 39	0	F	182,00	87,00	92,00	99,00	7,61	32,00	52,00	62,50	51,00	55,00	7,84	90,00	95,00	5,56	34,00	40,00	17,65	59,00	62,00	5,08	4,18	5,21
P1 - 41	0	B	171,00	63,00	100,00	104,00	4,00	63,00	66,00	4,76	54,00	56,00	3,70	101,00	104,00	2,97	72,00	76,00	5,56	71,00	73,00	2,82	24,78	26,79
P1 - 43	0	B	176,00	53,00	103,00	105,00	1,94	71,00	74,00	4,23	73,00	78,00	6,85	102,00	104,00	1,96	78,00	91,00	16,67	72,00	84,00	16,67	0,05	3,22
P1 - 45	0	B	167,00	55,00	95,00	97,00	2,11	58,00	62,00	6,90	66,00	68,00	3,03	94,00	98,00	4,26	59,00	64,00	8,47	67,00	71,00	5,97	0,50	3,45
P1 - 47	0	B	162,00	59,00	89,00	92,00	3,37	51,00	58,00	13,73	58,00	62,00	6,90	92,00	98,00	6,52	48,00	51,00	6,25	61,00	60,00	-1,64	0,18	2,33
P1 - 49	0	B	157,00	46,00	99,00	105,00	6,06	63,00	69,00	9,52	69,00	74,00	7,25	99,00	104,00	5,05	48,00	54,00	12,50	67,00	70,00	4,48	1,30	3,65
P1 - 51	0	B	161,00	55,00	104,00	108,00	3,85	50,00	54,00	8,00	72,00	78,00	8,33	111,00	112,00	0,90	51,00	59,00	15,69	67,00	71,00	5,97	26,15	29,32
P1 - 53	0	F	169,00	53,00	101,00	104,00	2,97	50,00	58,00	16,00	67,00	74,00	10,45	94,00	99,00	5,32	70,00	78,00	11,43	71,00	74,00	4,23	1,18	3,15
P1 - 55	0	B	168,00	64,00	87,00	91,00	4,598	32,00	47,00	46,88	41,00	50,00	21,95	89,00	91,00	2,25	30,00	45,00	50,00	46,00	54,00	17,39	1,28	4,98
AVERAGES					102,18	105,04	2,80	56,64	62,04	9,52	63,46	67,43	6,25	101,11	104,68	3,53	62,29	67,46	8,31	61,96	66,43	7,20	5,22	6,92
Absolute Change							2,86			5,39			3,96			3,57			5,18			4,46		
Standard deviation					10,53	9,60	2,96	13,27	10,93	13,86	11,23	10,70	5,50	10,45	9,41	2,51	15,98	14,50	9,73	10,40	10,09	5,94	6,87	7,26
T-TEST - PAIRED and SD Change					0,000		-8,89	0,000		-17,666	0,000		-4,693	0,000		-9,938	0,000		-9,224	0,000		-2,993	0,000	
P1 - 02	1	F	165,00	63,00	103,00	114,00	10,68	53,00	62,00	16,98	84,00	88,00	4,76	103,00	115,00	11,65	76,00	81,00	6,58	59,00	65,00	10,17	3,05	12,56
P1 - 04	1	F	181,00	54,00	115,00	121,00	5,22	71,00	82,00	15,49	87,00	92,00	5,75	111,00	120,00	8,11	72,00	80,00	11,11	59,00	68,00	15,25	3,65	11,54
P1 - 06	1	B	172,00	59,00	115,00	124,00	7,83	65,00	72,00	10,77	65,00	78,00	20,00	134,00	135,00	0,75	85,00	92,00	8,24	72,00	84,00	16,67	6,51	14,52
P1 - 08	1	B	170,00	69,40	105,00	116,00	10,48	69,00	78,00	13,04	70,00	81,00	15,71	105,00	116,00	10,48	68,00	79,00	16,18	65,00	81,00	24,62	3,12	6,57
P1 - 10	1	F	171,00	70,00	101,00	115,00	13,86	63,00	67,00	6,35	60,00	68,00	13,33	97,00	114,00	17,53	67,00	78,00	16,42	64,00	72,00	12,50	2,87	7,89
P1 - 12	1	B	166,00	62,90	116,00	122,00	5,17	60,00	72,00	20,00	78,00	86,00	10,26	116,00	120,00	3,45	80,00	91,00	13,75	67,00	78,00	16,42	3,00	15,89
P1 - 14	1	B	163,00	56,00	127,00	129,00	1,57	75,00	84,00	12,00	67,00	76,00	13,43	124,00	126,00	1,61	77,00	82,00	6,49	57,00	65,00	14,04	3,71	16,78
P1 - 16	1	F	168,00	85,00	102,00	114,00	11,76	51,00	64,00	25,49	68,00	78,00	14,71	107,00	118,00	10,28	73,00	84,00	15,07	42,00	64,00	52,38	2,63	14,56
P1 - 18	1	B	163,00	68,00	98,00	109,00	11,22	52,00	64,00	23,08	62,00	78,00	25,81	97,00	111,00	14,43	42,00	57,00	35,71	48,00	56,00	16,67	3,83	8,54
P1 - 20	1	F	159,00	65,00	110,00	116,00	5,45	59,00	65,00	10,17	52,00	61,00	17,31	97,00	112,00	15,46	73,00	84,00	15,07	54,00	65,00	20,37	2,21	12,79
P1 - 22	1	B	164,00	48,00	109,00	111,00	1,83	71,00	79,00	11,27	73,00	84,00	15,07	113,00	116,00	2,65	70,00	84,00	20,00	70,00	78,00	11,43	3,48	8,29
P1 - 24	1	F	172,00	60,00	114,00	118,00	3,51	74,00	84,00	13,51	87,00	95,00	9,20	111,00	116,00	4,50	64,00	75,00	17,19	65,00	78,00	20,00	3,72	16,79
P1 - 26	1	B	153,00	46,20	99,00	110,00	11,11	69,00	78,00	13,04	70,00	81,00	15,71	103,00	115,00	11,65	63,00	76,00	20,63	68,00	79,00	16,18	3,41	13,28
P1 - 28	1	F	167,00	50,00	115,00	121,00	5,22	73,00	79,00	8,22	78,00	85,00	8,97	113,00	116,00	2,65	71,00	81,00	14,08	80,00	89,00	11,25	4,31	16,28
P1 - 30	1	B	175,00	85,00	98,00	108,00	10,20	51,00	64,00	25,49	73,00	79,00	8,22	111,00	119,00	7,21	72,00	84,00	16,67	52,00	69,00	32,69	3,78	15,17
P1 - 32	1	F	163,00	50,00	104,00	114,00	9,62	43,00	49,00	13,95	60,00	74,00	23,33	79,00	92,00	16,46	57,00	59,00	3,51	52,00	70,00	34,62	2,32	9,74
P1 - 34	1	B	177,00	97,00	99,00	115,00	16,16	53,00	59,00	11,32	69,00	81,00	17,39	87,00	98,00	12,64	45,00	58,00	28,89	65,00	74,00	13,85	1,50	8,62
P1 - 36	1	F	174,00	78,00	100,00	114,00	14,00	54,00	67,00	24,07	85,00	91,00	7,06	101,00	116,00	14,85	62,00	89,00	43,55	84,00	91,00	8,33	18,42	29,29
P1 - 38	1	F	187,00	89,00	95,00	108,00	13,68	64,00	74,00	15,63	72,00	85,00	18,06	99,00	103,00	4,04	65,00	74,00	13,85	72,00	85,00	18,06	1,11	12,46
P1 - 40	1	B	180,00	72,00	92,00	101,00	9,78	51,00	64,00	25,49	61,00	84,00	37,70	94,00	106,00	12,77	48,00	52,00	8,33	60,00	74,00	23,33	0,59	14,65
P1 - 42	1	F	175,00	74,00	93,00	98,00	5,38	62,00	70,00	12,90	85,00	91,00	7,06	91,00	110,00	20,88	69,00	84,00	21,74	79,00	89,00	12,66	1,27	16,54
P1 - 44	1	B	177,00	78,00	105,00	116,00	10,48	64,00	66,00	3,13	77,00	86,00	11,69	104,00	114,00	9,62	62,00	75,00	20,97	75,00	89,00	18,67	2,01	32,85
P1 - 46	1	F	159,00	50,00	96,00	107,00	11,46	60,00	71,00	18,33	80,00	94,00	17,50	114,00	120,00	5,26	70,00	88,00	25,71	83,00	95,00	14,46	9,26	18,63
P1 - 48	1	B	176,00	62,00	101,00	111,00	9,90	72,00	78,00	8,33	68,00	79,00	16,18	104,00	118,00	13,46	76,00	86,00	13,16	61,00	74,00	21,31	23,08	34,22
P1 - 50	1	B	175,00	71,00	102,00	112,00	9,80	62,00	74,00	19,35	81,00	90,00	11,11	100,00	115,00	15,00	69,00	74,00	7,25	72,00	88,00	22,22	2,47	25,61
P1 - 52	1	B	169,00	62,00	109,00	118,00	8,26	67,00	74,00	10,45	79,00	84,00	6,33	101,00	114,00	12,87	70,00	84,00	20,00	89,00	92,00	3,37	1,52	16,49
P1 - 54	1	F	185,00	76,00	105,00	113,00	7,62	52,00	59,00	13,46	68,00	78,00	14,71	95,00	105,00	10,53	43,00	59,00	37,21	71,00	84,00	18,31	4,36	8,62
P1 - 56	1	B	176,00	62,00	113,00	124,00	9,73	60,00	69,00	15,00	66,00	74,00	12,12	102,00	111,00	8,82	72,00	84,00	16,67	53,00	66,00	24,53	6,17	12,26
AVERAGES					105,04	114,25	8,77	61,43	70,29	14,42	72,32	82,18	13,63	104,04	113,96	9,54	66,46	77,64	16,82	65,64	77,21	17,63	4,55	15,41
Absolute Change							9,21			8,86			9,86			9,93			11,18			11,57		
Standard deviation					8,28	6,78	3,68	8,60	8,38	5,96	9,24	7,75	6,96	11,12	8,20	5,32	10,84	10,94	9,57	11,53	10,35	9,41	4,95	7,16
T-TEST - PAIRED					0,000		-18,11	0,000		-2,61	0,000		-16,13	0,000		-26,23	0,000		0,93	0,000		-10,27	0,000	
T-TEST - UNPAIRED (DIFF BETW. CONTROL VS INTERVENTION)					0,26	0,00		0,12	0,00		0,00	0,00		0,31	0,00		0,26	0,00		0,22	0,00		0,68	0,00

% Change	Push-up Plus Test	Push-up Plus Test	% Change	CKCUEST											
				1	1	% Change	2	2	% Change	3	3	% Change	Avg	Avg	Avg change
19,54	7,00	9,00	28,57	20,00	20,00	0,00	19,00	20,00	5,26	20,00	19,00	-5,00	19,67	19,67	0,09
-8,21	8,00	12,00	50,00	16,00	18,00	12,50	18,00	18,00	0,00	15,00	17,00	13,33	16,33	17,67	8,61
11,07	12,00	15,00	25,00	20,00	22,00	10,00	22,00	22,00	0,00	22,00	21,00	-4,55	21,33	21,67	1,82
27,12	9,00	15,00	66,67	17,00	18,00	5,88	17,00	17,00	0,00	14,00	16,00	14,29	16,00	17,00	6,72
9,89	11,00	15,00	36,36	22,00	20,00	-9,09	21,00	21,00	0,00	22,00	22,00	0,00	21,67	21,00	-3,03
35,70	14,00	24,00	71,43	19,00	20,00	5,26	20,00	21,00	5,00	17,00	20,00	17,65	18,67	20,33	9,30
25,50	9,00	13,00	44,44	18,00	18,00	0,00	20,00	16,00	-20,00	19,00	18,00	-5,26	19,00	17,33	-8,42
162,35	10,00	18,00	80,00	16,00	15,00	-6,25	18,00	15,00	-16,67	20,00	16,00	-20,00	18,00	15,33	-14,31
12,23	5,00	7,00	40,00	16,00	18,00	12,50	17,00	19,00	11,76	17,00	18,00	5,88	16,67	18,33	10,05
33,43	8,00	12,00	50,00	24,00	25,00	4,17	23,00	25,00	8,70	23,00	26,00	13,04	23,33	25,33	8,64
20,51	11,00	17,00	54,55	19,00	20,00	5,26	21,00	20,00	-4,76	22,00	19,00	-13,64	20,67	19,67	-4,38
50,00	27,00	32,00	18,52	17,00	17,00	0,00	22,00	18,00	-18,18	22,00	17,00	-22,73	20,33	17,33	-13,64
-12,90	12,00	19,00	58,33	18,00	19,00	5,56	19,00	20,00	5,26	16,00	19,00	18,75	17,67	19,33	9,86
218,42	15,00	19,00	26,67	16,00	17,00	6,25	16,00	16,00	0,00	17,00	18,00	5,88	16,33	17,00	4,04
31,71	9,00	14,00	55,56	14,00	15,00	7,14	19,00	14,00	-26,32	17,00	16,00	-5,88	16,67	15,00	-8,35
47,68	16,00	21,00	31,25	18,00	18,00	0,00	18,00	19,00	5,56	17,00	17,00	0,00	17,67	18,00	1,85
104,05	13,00	16,00	23,08	12,00	15,00	25,00	13,00	14,00	7,69	14,00	13,00	-7,14	13,00	14,00	8,52
2,59	9,00	12,00	33,33	8,00	12,00	50,00	8,00	13,00	62,50	9,00	15,00	66,67	8,33	13,33	59,72
17,20	8,00	11,00	37,50	16,00	17,00	6,25	19,00	19,00	0,00	21,00	19,00	-9,52	18,67	18,33	-1,09
24,64	4,00	9,00	125,00	18,00	19,00	5,56	20,00	18,00	-10,00	16,00	19,00	18,75	18,00	18,67	4,77
8,11	24,00	28,00	16,67	19,00	20,00	5,26	20,00	20,00	0,00	19,00	19,00	0,00	19,33	19,67	1,75
6340,00	21,00	24,00	14,29	17,00	19,00	11,76	20,00	17,00	-15,00	23,00	19,00	-17,39	20,00	18,33	-6,88
590,00	27,00	31,00	14,81	17,00	16,00	-5,88	21,00	17,00	-19,05	22,00	16,00	-27,27	20,00	16,33	-17,40
1194,44	17,00	21,00	23,53	12,00	14,00	16,67	19,00	15,00	-21,05	18,00	16,00	-11,11	16,33	15,00	-5,17
180,77	15,00	19,00	26,67	15,00	14,00	-6,67	17,00	18,00	5,88	23,00	14,00	-39,13	18,33	15,33	-13,30
12,12	12,00	17,00	41,67	17,00	18,00	5,88	19,00	19,00	0,00	20,00	17,00	-15,00	18,67	18,00	-3,04
166,95	5,00	8,00	60,00	7,00	14,00	100,00	17,00	17,00	0,00	14,00	15,00	7,14	12,67	15,33	35,71
289,06	5,00	11,00	120,00	11,00	13,00	18,18	10,00	11,00	10,00	10,00	14,00	40,00	10,33	12,67	22,73
32,69	12,25	16,75	36,73	16,39	17,54	6,97	18,32	17,82	-2,73	18,18	17,68	-2,75	17,63	17,68	0,50
1,71			4,50			1,14			-0,50			-0,50			0,05
1200,47	6,28	6,60	28,02	3,76	2,89	20,92	3,36	2,97	16,40	3,81	2,70	21,08	3,33	2,73	15,82
5,683	0,000		5,224	0,002		-23,327	0,264		-11,514	0,432		-29,280	0,900		-17,945
311,80	10,00	17,00	70,00	17,00	21,00	23,53	18,00	22,00	22,22	17,00	22,00	29,41	17,33	21,67	25,05
216,16	18,00	23,00	27,78	23,00	26,00	13,04	22,00	25,00	13,64	20,00	26,00	30,00	21,67	25,67	18,89
123,04	13,00	26,00	100,00	24,00	28,00	16,67	23,00	28,00	21,74	26,00	27,00	3,85	24,33	27,67	14,08
110,58	8,00	19,00	137,50	19,00	23,00	21,05	17,00	23,00	35,29	18,00	21,00	16,67	18,00	22,33	24,34
174,91	5,00	14,00	180,00	13,00	19,00	46,15	15,00	20,00	33,33	16,00	19,00	18,75	14,67	19,33	32,75
429,67	8,00	26,00	225,00	19,00	24,00	26,32	20,00	23,00	15,00	20,00	22,00	10,00	19,67	23,00	17,11
352,29	11,00	26,00	136,36	19,00	23,00	21,05	22,00	22,00	0,00	18,00	23,00	27,78	19,67	22,67	16,28
453,61	3,00	12,00	300,00	16,00	22,00	37,50	16,00	23,00	43,75	17,00	21,00	23,53	16,33	22,00	34,93
122,98	6,00	15,00	150,00	17,00	24,00	41,18	17,00	23,00	35,29	16,00	23,00	43,75	16,67	23,33	40,07
478,73	9,00	17,00	88,89	16,00	24,00	50,00	21,00	26,00	23,81	20,00	23,00	15,00	19,00	24,33	29,60
138,22	12,00	23,00	91,67	20,00	24,00	20,00	23,00	25,00	8,70	21,00	26,00	23,81	21,33	25,00	17,50
351,34	3,00	18,00	500,00	18,00	23,00	27,78	18,00	23,00	27,78	17,00	23,00	35,29	17,67	23,00	30,28
289,44	14,00	28,00	100,00	20,00	24,00	20,00	20,00	25,00	25,00	17,00	23,00	35,29	19,00	24,00	26,76
277,73	7,00	15,00	114,29	17,00	24,00	41,18	18,00	23,00	27,78	16,00	23,00	43,75	17,00	23,33	37,57
301,32	10,00	21,00	110,00	17,00	21,00	23,53	17,00	23,00	35,29	16,00	24,00	50,00	16,67	22,67	36,27
319,83	12,00	23,00	91,67	11,00	19,00	72,73	14,00	20,00	42,86	12,00	22,00	83,33	12,33	20,33	66,31
474,67	11,00	19,00	72,73	10,00	18,00	80,00	12,00	20,00	66,67	13,00	22,00	69,23	11,67	20,00	71,97
59,01	16,00	25,00	56,25	16,00	21,00	31,25	19,00	22,00	15,79	20,00	21,00	5,00	18,33	21,33	17,35
1022,52	8,00	16,00	100,00	16,00	23,00	43,75	20,00	24,00	20,00	19,00	24,00	26,32	18,33	23,67	30,02
2383,05	5,00	14,00	180,00	17,00	24,00	41,18	18,00	24,00	33,33	19,00	25,00	31,58	18,00	24,33	35,36
1202,36	20,00	31,00	55,00	26,00	28,00	7,69	15,00	27,00	80,00	14,00	26,00	85,71	18,33	27,00	57,80
1534,33	20,00	29,00	45,00	18,00	24,00	33,33	19,00	22,00	15,79	20,00	23,00	15,00	19,00	23,00	21,37
101,19	33,00	38,00	15,15	16,00	21,00	31,25	15,00	20,00	33,33	17,00	21,00	23,53	16,00	20,67	29,37
48,27	11,00	22,00	100,00	12,00	19,00	58,33	13,00	23,00	76,92	13,00	22,00	69,23	12,67	21,33	68,16
936,84	22,00	28,00	27,27	15,00	21,00	40,00	25,00	24,00	-4,00	23,00	26,00	13,04	21,00	23,67	16,35
984,87	20,00	28,00	40,00	23,00	26,00	13,04	25,00	25,00	0,00	24,00	25,00	4,17	24,00	25,33	5,74
97,71	8,00	16,00	100,00	15,00	19,00	26,67	13,00	19,00	46,15	15,00	21,00	40,00	14,33	19,67	37,61
98,70	20,00	26,00	30,00	19,00	24,00	26,32	20,00	22,00	10,00	23,00	22,00	-4,35	20,67	22,67	10,66
238,75	12,25	21,96	79,30	17,46	22,75	30,27	18,39	23,07	25,44	18,11	23,07	27,42	17,99	22,96	27,71
10,86			9,71			5,29			4,68			4,96			4,98
533,39	6,82	6,24	98,50	3,71	2,62	17,15	3,54	2,16	20,86	3,40	1,96	23,31	3,12	2,07	17,14
44,68	0,000		-8,48	0,000		-29,33	0,000		-39,04	0,000		-42,37	0,000		-33,79
	1,00	0,00		0,29	0,00		0,94	0,00		0,94	0,00		0,68	0,00	

Protocol 2: Control Group = RED; Intervention Group = GREEN

Participant		Rugby Position	Height	Body Weight	Isometric Pull-up Hold Test	Isometric Pull-up Hold Test	% Change	Push-up Test (1 min)	Push-up Test (1 min)	% Change	Shoulder Press (60% BW)	Shoulder Press (60% BW)	% Change
P2 - 01	0	F	171	91	25,28	28,26	11,79	46,00	51,00	10,87	16,00	22,00	37,50
P2 - 03	0	F	175	102	0,00	0,00	0,00	38,00	34,00	-10,53	0,10	2,00	1900,00
P2 - 05	0	F	173	84	38,83	12,74	-67,19	60,00	65,00	8,33	14,00	18,00	28,57
P2 - 07	0	F	178	74	28,03	30,90	10,24	27,00	35,00	29,63	7,00	10,00	42,86
P2 - 09	0	F	175	70	67,74	65,11	-3,88	60,00	61,00	1,67	10,00	14,00	40,00
P2 - 11	0	B	182	73	26,22	27,33	4,23	36,00	39,00	8,33	8,00	10,00	25,00
P2 - 13	0	B	178	64	44,15	29,84	-32,41	60,00	52,00	-13,33	9,00	13,00	44,44
P2 - 15	0	B	171	65	40,89	42,69	4,40	53,00	54,00	1,89	3,00	8,00	166,67
P2 - 17	0	B	178	75	42,99	42,89	-0,23	64,00	66,00	3,13	14,00	16,00	14,29
P2 - 19	0	B	171	60	51,28	50,21	-2,09	40,00	49,00	22,50	9,00	13,00	44,44
P2 - 21	0	B	166	68	22,05	23,68	7,39	34,00	36,00	5,88	5,00	8,00	60,00
P2 - 23	0	F	179	95	8,13	9,88	21,53	30,00	32,00	6,67	0,10	2,00	1900,00
P2 - 25	0	F	176	93	0,10	1,25	1150,00	13,00	18,00	38,46	1,00	2,00	100,00
P2 - 27	0	B	164	55	49,78	50,11	0,66	44,00	48,00	9,09	10,00	14,00	40,00
P2 - 29	0	B	169	65	32,54	34,54	6,15	51,00	55,00	7,84	8,00	11,00	37,50
P2 - 31	0	F	174	66	49,67	51,47	3,62	44,00	49,00	11,36	11,00	14,00	27,27
P2 - 33	0	B	171	69	32,16	34,57	7,49	36,00	45,00	25,00	8,00	12,00	50,00
P2 - 35	0	F	181	88	26,14	26,77	2,41	48,00	57,00	18,75	2,00	3,00	50,00
P2 - 37	0	F	177	99	25,14	32,79	30,43	25,00	28,00	12,00	3,00	7,00	133,33
P2 - 39	0	F	179	92	12,46	11,25	-9,71	17,00	22,00	29,41	0,10	0,10	0,00
Mean			174,40	77,40	31,18	30,31	-2,77	41,30	44,80	8,47	6,92	9,96	43,96
Absolute Change							-0,87			3,50			3,04
Standard Deviation					17,66	17,36	257,98	14,49	13,77	12,95	4,94	5,94	570,05
T-TEST - PAIRED and SD change					0,597		-1,73	0,001		-4,98	0,000		20,29
P2 - 02	1	F	180	115	0,00	0,00	0,00	30,00	35,00	16,67	0,10	1,00	900,00
P2 - 04	1	F	176	86	0,00	0,00	0,00	23,00	25,00	8,70	1,00	3,00	200,00
P2 - 06	1	F	185	91	3,00	7,76	158,67	30,00	48,00	60,00	0,10	6,00	5900,00
P2 - 08	1	F	187	96	22,11	29,81	34,83	30,00	33,00	10,00	1,00	6,00	500,00
P2 - 10	1	F	170	68	46,33	51,62	11,42	62,00	73,00	17,74	13,00	16,00	23,08
P2 - 12	1	F	182	78	62,16	64,25	3,36	49,00	53,00	8,16	3,00	14,00	366,67
P2 - 14	1	B	170	64	42,41	48,32	13,94	52,00	55,00	5,77	2,00	12,00	500,00
P2 - 16	1	B	170	68	33,08	39,55	19,56	50,00	62,00	24,00	12,00	23,00	91,67
P2 - 18	1	B	182	71	47,69	51,69	8,39	50,00	61,00	22,00	12,00	24,00	100,00
P2 - 20	1	B	185	71	33,65	48,59	44,40	40,00	56,00	40,00	11,00	26,00	136,36
P2 - 22	1	F	177	63	48,02	51,48	7,21	30,00	38,00	26,67	8,00	15,00	87,50
P2 - 24	1	F	163	53	2,86	5,47	91,26	26,00	33,00	26,92	15,00	21,00	40,00
P2 - 26	1	F	159	54	4,26	7,41	73,94	29,00	39,00	34,48	12,00	16,00	33,33
P2 - 28	1	B	169	53	36,79	39,15	6,41	46,00	51,00	10,87	8,00	14,00	75,00
P2 - 30	1	F	164	48	13,59	15,06	10,82	48,00	58,00	20,83	12,00	19,00	58,33
P2 - 32	1	F	163	43	58,13	59,64	2,60	56,00	61,00	8,93	7,00	18,00	157,14
P2 - 34	1	B	168	106	48,76	46,22	-5,21	49,00	60,00	22,45	0,10	2,00	1900,00
P2 - 36	1	B	172	57	41,23	44,57	8,10	51,00	59,00	15,69	5,00	11,00	120,00
P2 - 38	1	B	172	74	28,65	35,68	24,54	34,00	47,00	38,24	6,00	15,00	150,00
P2 - 40	1	B	172	72	25,44	29,18	14,70	24,00	33,00	37,50	4,00	9,00	125,00
Mean			173,30	71,55	29,91	33,77	12,92	40,45	49,00	21,14	6,62	13,55	104,84
Absolute Change							3,86			8,55			6,94
Standard Deviation					20,15	20,72	39,79	12,05	12,99	13,81	5,05	7,33	1327,19
T-TEST - PAIRED and SD change					0,000		2,86	0,000		7,76	0,000		45,11
T-TEST - UNPAIRED (DIFF BETW. CONTROL VS INTERVENTION)					0,83	0,57		0,84	0,33		0,85	0,10	

Protocol 3: Control Group = RED; Intervention Group = GREEN

Participant	Code	Position	Height	Body Weight	Y-Balance															
					L-Side	L-Side	% Change	L-Top	L-Top	% Change	L-Bottom	L-Bottom	% Change	R-Side	R-Side	% Change	R-Top	R-Top	% Change	R-Bottom
P3 - 01	0	B	171	65	93	95	2,15	61	62	1,64	65	66	1,54	103	105	1,94	70	70	0,00	73
P3 - 03	0	B	179	64	105	106	0,95	70	70	0,00	62	68	9,68	95	99	4,21	75	81	8,00	78
P3 - 05	0	F	174	79	101	99	-1,98	42	51	21,43	62	66	6,45	123	120	-2,44	62	64	3,23	84
P3 - 07	0	B	182	77	124	131	5,65	80	81	1,25	83	82	-1,20	134	132	-1,49	73	73	0,00	70
P3 - 09	0	F	178	84	103	104	0,97	68	74	8,82	78	80	2,56	105	109	3,81	69	71	2,90	72
P3 - 11	0	B	179	86	128	130	1,56	61	61	0,00	64	66	3,13	107	111	3,74	54	60	11,11	63
P3 - 13	0	F	188	93	121	121	0,00	68	71	4,41	81	80	-1,23	104	110	5,77	70	79	12,86	80
P3 - 15	0	B	175	66	103	105	1,94	52	54	3,85	74	79	6,76	109	111	1,83	56	62	10,71	72
P3 - 17	0	F	175	98	106	111	4,72	74	79	6,76	74	78	5,41	109	110	0,92	75	72	-4,00	76
P3 - 19	0	F	174	89	99	101	2,02	62	68	9,68	74	78	5,41	100	102	2,00	64	66	3,13	62
P3 - 21	0	F	175	103	98	99	1,02	62	60	-3,23	74	78	5,41	97	99	2,06	61	68	11,48	64
P3 - 23	0	B	180	98	100	105	5,00	65	62	-4,62	63	64	1,59	98	100	2,04	78	76	-2,56	89
P3 - 25	0	B	182	72	96	100	4,17	62	63	1,61	66	70	6,06	99	97	-2,02	74	78	5,41	61
P3 - 27	0	F	178	68	122	126	3,28	77	79	2,60	105	105	0,00	119	124	4,20	79	84	6,33	83
P3 - 29	0	B	187	66	120	122	1,67	70	78	11,43	103	106	2,91	115	112	-2,61	74	79	6,76	90
P3 - 31	0	B	174	60	108	109	0,93	73	77	5,48	74	76	2,70	111	120	8,11	78	84	7,69	72
P3 - 33	0	B	171	61	117	123	5,13	41	49	19,51	52	60	15,38	105	110	4,76	61	69	13,11	45
P3 - 35	0	B	183	77	133	134	0,75	80	89	11,25	88	91	3,41	132	139	5,30	76	81	6,58	91
P3 - 37	0	B	177	67	110	116	5,45	77	79	2,60	75	74	-1,33	115	117	1,74	73	76	4,11	76
P3 - 39	0	F	169	69	101	106	4,95	65	66	1,54	58	61	5,17	104	110	5,77	62	69	11,29	62
P3 - 41	0	B	174	71	111	116	4,50	78	79	1,28	81	80	-1,23	114	116	1,75	79	76	-3,80	68
P3 - 43	0	B	175	78	106	111	4,72	64	69	7,81	78	87	11,54	104	110	5,77	59	64	8,47	71
P3 - 45	0	B	178	74	100	106	6,00	64	68	6,25	59	62	5,08	106	110	3,77	63	62	-1,59	62
Mean			177,30	76,74	108,91	112,00	2,83	65,91	69,09	4,82	73,61	76,39	3,78	109,04	111,87	2,59	68,91	72,35	4,98	72,35
Absolute Change							3,09			3,17			2,78			2,83			3,43	
Standard Deviation					11,09	11,43	2,19	10,52	10,35	6,38	13,19	12,46	4,20	10,33	10,30	2,85	7,83	7,32	5,37	11,05
T-TEST - PAIRED and SD Change					0,00		2,99	0,00		-1,61	0,00		-5,54	0,00		-0,35	0,00		-6,54	0,00
P3 - 02	1	F	182	80	114	118	3,51	78	85	8,97	65	72	10,77	113	119	5,31	65	82	26,15	71
P3 - 04	1	F	172	70	116	119	2,59	64	77	20,31	71	79	11,27	111	115	3,60	72	75	4,17	76
P3 - 06	1	F	185	77	131	134	2,29	64	72	12,50	87	90	3,45	125	126	0,80	80	87	8,75	96
P3 - 08	1	F	177	75	122	125	2,46	61	69	13,11	83	88	6,02	116	120	3,45	65	74	13,85	80
P3 - 10	1	B	183	75	122	130	6,56	73	85	16,44	84	90	7,14	123	125	1,63	55	62	12,73	77
P3 - 12	1	F	182	111	108	114	5,56	43	58	34,88	77	86	11,69	106	119	12,26	52	60	15,38	77
P3 - 14	1	F	173	86	114	124	8,77	58	68	17,24	91	95	4,40	112	120	7,14	72	84	16,67	80
P3 - 16	1	B	173	69	107	114	6,54	66	72	9,09	72	76	5,56	113	120	6,19	66	78	18,18	67
P3 - 18	1	F	176	106	109	120	10,09	61	69	13,11	82	91	10,98	111	120	8,11	58	68	17,24	82
P3 - 20	1	F	171	115	94	104	10,64	58	69	18,97	62	78	25,81	98	106	8,16	57	69	21,05	58
P3 - 22	1	B	181	82	114	124	8,77	74	89	20,27	84	96	14,29	105	121	15,24	72	86	19,44	63
P3 - 24	1	B	171	65	98	112	14,29	63	87	38,10	62	84	35,48	102	116	13,73	61	84	37,70	60
P3 - 26	1	B	184	72	120	126	5,00	69	78	13,04	97	99	2,06	127	135	6,30	80	94	17,50	94
P3 - 28	1	B	184	70	122	132	8,20	79	90	13,92	100	111	11,00	115	137	19,13	76	95	25,00	98
P3 - 30	1	F	186	101	122	126	3,28	66	78	18,18	92	100	8,70	136	136	0,00	71	84	18,31	77
P3 - 32	1	B	182	95	109	120	10,09	72	72	0,00	61	87	42,62	107	109	1,87	64	67	4,69	72
P3 - 34	1	B	170	70	116	129	11,21	61	84	37,70	83	96	15,66	127	131	3,15	71	86	21,13	83
P3 - 36	1	B	180	74	104	116	11,54	53	59	11,32	61	74	21,31	102	115	12,75	52	61	17,31	60
P3 - 38	1	F	170	68	98	111	13,27	71	86	21,13	62	87	40,32	100	116	16,00	70	87	24,29	61
P3 - 40	1	B	174	72	99	116	17,17	64	79	23,44	54	78	44,44	106	112	5,66	60	79	31,67	51
P3 - 42	1	F	168	98	89	102	14,61	65	79	21,54	62	81	30,65	86	99	15,12	58	72	24,14	59
P3 - 44	1	B	172	76	115	126	9,57	65	87	33,85	62	84	35,48	112	120	7,14	63	79	25,40	62
P3 - 46	1	F	174	79	99	106	7,07	62	78	25,81	71	89	25,35	101	116	14,85	64	85	32,81	72
Mean			176,96	82,00	110,52	119,48	8,10	64,78	76,96	18,79	75,00	87,43	16,58	111,04	119,70	7,79	65,39	78,17	19,55	72,87
Absolute Change							8,96			12,17			12,43			8,65			12,78	
Standard Deviation					10,73	8,82	4,20	7,98	9,08	9,69	13,42	9,40	13,66	11,30	9,23	5,60	8,14	10,09	8,27	12,76
T-TEST - PAIRED					0,00		-17,85	0,00		13,78	0,00		-29,91	0,00		-18,32	0,00		23,92	0,00
T-TEST - UNPAIRED (DIFF BETW. CONTROL VS INTERVENTION)					0,62	0,02		0,68	0,01		0,72	0,00		0,53	0,01		0,14	0,03		0,88

R-Bottom	% Change	Scapular Retraction Test (sec)	Scapular Retraction Test (sec)	% Change	Push-up Plus Test	Push-up Plus Test	% Change	CKCUEST											
								1	1	% Change	2	2	% Change	3	3	% Change	Avg	Avg	Avg change
76	4,11	23,15	25,32	9,37	19	18	-5,26	24	25	4,17	25	26	4,00	25	24	-4,00	18,50	18,75	1,04
82	5,13	14,2	16,32	14,93	13	14	7,69	16	18	12,50	18	19	5,56	19	19	0,00	13,25	14,00	4,51
82	-2,38	14,22	18,95	33,26	22	23	4,55	19	19	0,00	18	18	0,00	19	19	0,00	14,00	14,00	0,00
71	1,43	8,26	7,25	-12,23	9	16	77,78	20	19	-5,00	24	18	-25,00	25	19	-24,00	17,25	14,00	-13,50
77	6,94	42,65	45,26	6,12	18	24	33,33	17	19	11,76	17	20	17,65	18	19	5,56	13,00	14,50	8,74
67	6,35	18,69	21,22	13,54	21	27	28,57	19	20	5,26	23	19	-17,39	23	20	-13,04	16,25	14,75	-6,29
84	5,00	32,51	31,62	-2,74	11	15	36,36	24	25	4,17	24	25	4,17	25	23	-8,00	18,25	18,25	0,08
78	8,33	15,03	18,22	21,22	23	24	4,35	19	18	-5,26	20	18	-10,00	20	19	-5,00	14,75	13,75	-5,07
77	1,32	35,78	42,03	17,47	25	32	28,00	21	20	-4,76	22	19	-13,64	23	21	-8,70	16,50	15,00	-6,77
68	9,68	26,89	29,22	8,66	14	19	35,71	23	21	-8,70	23	20	-13,04	25	21	-16,00	17,75	15,50	-9,43
66	3,13	16,23	21,02	29,51	7	10	42,86	18	18	0,00	18	19	5,56	16	18	12,50	13,00	13,75	4,51
84	-5,62	21,46	23,44	9,23	11	14	27,27	18	19	5,56	18	20	11,11	17	18	5,88	13,25	14,25	5,64
65	6,56	7,23	9,45	30,71	18	25	38,89	21	21	0,00	22	21	-4,55	21	20	-4,76	16,00	15,50	-2,33
90	8,43	23,14	32,16	38,98	13	18	38,46	22	23	4,55	22	22	0,00	20	23	15,00	16,00	17,00	4,89
91	1,11	9,15	11,26	23,06	14	16	14,29	25	26	4,00	23	23	0,00	24	21	-12,50	18,00	17,50	-2,13
80	11,11	4,23	6,01	42,08	13	15	15,38	21	19	-9,52	20	20	0,00	21	19	-9,52	15,50	14,50	-4,76
52	15,56	8,26	14,22	72,15	25	26	4,00	17	19	11,76	18	17	-5,56	18	19	5,56	13,25	13,75	2,94
96	5,49	29,31	39,15	33,57	29	32	10,34	30	27	-10,00	22	26	18,18	24	25	4,17	19,00	19,50	3,09
79	3,95	9,15	15,32	67,43	19	22	15,79	22	22	0,00	21	20	-4,76	21	21	0,00	16,00	15,75	-1,19
64	3,23	5,12	6,11	19,34	11	16	45,45	18	19	5,56	17	18	5,88	17	17	0,00	13,00	13,50	2,86
62	-8,82	15,65	17,55	12,14	18	24	33,33	17	17	0,00	18	18	0,00	22	19	-13,64	14,25	13,50	-3,41
78	9,86	12,18	10,33	-15,19	21	26	23,81	18	19	5,56	19	21	10,53	21	19	-9,52	14,50	14,75	1,64
65	4,84	4,78	9,11	90,59	18	22	22,22	19	20	5,26	18	20	11,11	20	19	-5,00	14,25	14,75	2,84
75,39	4,21	17,27	20,46	18,44	17,04	20,78	21,94	20,35	20,57	1,07	20,43	20,30	-0,64	21,04	20,09	-4,55	15,46	15,24	-1,03
	3,04			3,19			3,74			0,22			-0,13			-0,96			-0,22
10,61	5,35	10,59	11,53	25,58	5,70	5,89	18,24	3,28	2,79	6,52	2,56	2,55	10,84	2,84	2,02	9,38	1,98	1,76	5,36
	-3,98	0,00		8,90	0,00		3,37	0,45		-14,93	0,79		-0,27	0,04		-28,75	0,37		-11,05
80	12,68	30,16	48,95	62,30	18	22	22,22	17	22	29,41	20	23	15,00	19	23	21,05	14,00	17,00	16,37
89	17,11	18,66	36,44	95,28	14	21	50,00	21	26	23,81	23	26	13,04	22	24	9,09	16,50	19,00	11,49
98	2,08	19,26	33,26	72,69	34	38	11,76	20	23	15,00	23	23	0,00	24	22	-8,33	16,75	17,00	1,67
86	7,50	41,02	59,12	44,12	25	31	24,00	16	24	50,00	18	23	27,78	21	23	9,52	13,75	17,50	21,83
84	9,09	12,65	26,33	108,14	19	29	52,63	20	25	25,00	25	26	4,00	24	26	8,33	17,25	19,25	9,33
84	9,09	45,62	62,65	37,33	8	19	137,50	22	26	18,18	21	27	28,57	20	25	25,00	15,75	19,50	17,94
92	15,00	42,89	58,46	36,30	18	29	61,11	23	29	26,09	24	27	12,50	21	28	33,33	17,00	21,00	17,98
81	20,90	26,22	39,48	50,57	33	39	18,18	22	26	18,18	21	25	19,05	22	25	13,64	16,25	19,00	12,72
91	10,98	16,44	32,05	94,95	13	26	100,00	19	23	21,05	20	23	15,00	20	22	10,00	14,75	17,00	11,51
72	24,14	26,45	46,15	74,48	3	15	400,00	17	21	23,53	17	21	23,53	16	21	31,25	12,50	15,75	19,58
84	33,33	6,21	19,26	210,14	9	16	77,78	19	21	10,53	21	23	9,52	20	22	10,00	15,00	16,50	7,51
79	31,67	5,98	18,26	205,35	13	22	69,23	23	26	13,04	23	28	21,74	23	27	17,39	17,25	20,25	13,04
101	7,45	26,02	49,44	90,01	24	32	33,33	24	29	20,83	23	28	21,74	23	29	26,09	17,50	21,50	17,16
105	7,14	15,12	29,31	93,85	19	26	36,84	24	30	25,00	21	29	38,10	24	28	16,67	17,25	21,75	19,94
90	16,88	36,15	63,06	74,44	6	19	216,67	24	31	29,17	21	30	42,86	23	27	17,39	17,00	22,00	22,35
80	11,11	45,26	66,33	46,55	16	25	56,25	23	24	4,35	22	26	18,18	22	25	13,64	16,75	18,75	9,04
99	19,28	19,26	39,26	103,84	26	34	30,77	21	24	14,29	22	25	13,64	24	24	0,00	16,75	18,25	6,98
87	45,00	12,33	42,22	242,42	13	24	84,62	13	19	46,15	15	19	26,67	16	18	12,50	11,00	14,00	21,33
90	47,54	17,49	28,96	65,58	8	18	125,00	20	28	40,00	21	27	28,57	20	26	30,00	15,25	20,25	24,64
90	76,47	6,32	16,03	153,64	12	23	91,67	18	24	33,33	19	25	31,58	19	26	36,84	14,00	18,75	25,44
78	32,20	12,66	29,65	134,20	4	17	325,00	14	19	35,71	16	18	12,50	16	19	18,75	11,50	14,00	16,74
79	27,42	6,32	26,48	318,99	23	30	30,43	20	22	10,00	20	21	5,00	22	22	0,00	15,50	16,25	3,75
91	26,39	19,23	42,49	120,96	21	31	47,62	22	26	18,18	22	25	13,64	24	25	4,17	17,00	19,00	9,00
87,39	19,93	22,07	39,72	79,95	16,48	25,48	54,62	20,09	24,70	22,94	20,78	24,70	18,83	21,09	24,22	14,85	15,49	18,40	14,15
	14,52			17,65			9,00			4,61			3,91			3,13			2,91
8,16	16,97	12,82	15,04	72,26	8,50	6,83	98,07	3,12	3,30	11,46	2,49	3,08	10,72	2,59	2,84	11,41	1,91	2,25	6,66
	-36,02	0,00		17,28	0,00		-19,67	0,00		5,69	0,00		23,97	0,00		9,71	0,00		18,02
0,00		0,17	0,00		0,79	0,02		0,78	0,00		0,64	0,00		0,96	0,00		0,95	0,00	

Isometric Pull-up Hold Test	Isometric Pull-up Hold Test	% Change	Push-up Test (1 min)	Push-up Test (1 min)	% Change	Shoulder Press (60% BW)	Shoulder Press (60% BW)	% Change
57,01	52,12	-8,58	64	66	3,13	0	1	100,00
41,91	42,69	1,86	52	52	0,00	2	4	100,00
13,64	26,22	92,23	64	65	1,56	1	4	300,00
54,62	52,55	-3,79	50	54	8,00	6	11	83,33
31,69	33,64	6,15	42	47	11,90	4	6	50,00
28,02	32,88	17,34	50	56	12,00	8	16	100,00
12,37	16,46	33,06	31	36	16,13	2	4	100,00
29,47	32,16	9,13	55	56	1,82	0	2	200,00
38,41	32,61	-15,10	57	61	7,02	6	6	0,00
22,81	26,26	15,12	58	59	1,72	8	10	25,00
5,21	3,23	-38,00	23	25	8,70	3	4	33,33
43,28	49,78	15,02	41	44	7,32	4	4	0,00
58,28	54,12	-7,14	52	54	3,85	4	5	25,00
43,34	49,03	13,13	51	53	3,92	11	14	27,27
52,86	51,2	-3,14	48	52	8,33	5	6	20,00
32,26	38,22	18,47	35	39	11,43	2	4	100,00
62,29	80,31	28,93	40	47	17,50	3	5	66,67
43,12	52,61	22,01	72	70	-2,78	21	23	9,52
43,03	38,26	-11,09	34	35	2,94	0	1	100,00
42,72	44,62	4,45	28	34	21,43	4	5	25,00
21,58	26,59	23,22	29	32	10,34	4	6	50,00
53,84	51,2	-4,90	47	51	8,51	6	6	0,00
38,42	42,61	10,91	45	47	4,44	7	6	-14,29
37,83	40,41	6,80	46,43	49,35	6,27	4,83	6,65	37,83
		2,57			2,91			1,83
15,56	15,70	24,19	12,63	11,69	5,93	4,51	5,12	71,63
0,05		0,92	0,00		-7,47	0,00		13,61
40,1	59,54	48,48	51	58	13,73	7	15	114,29
43,18	62,26	44,19	56	64	14,29	16	23	43,75
20,37	36,87	81,00	51	61	19,61	3	8	166,67
38,99	48,69	24,88	62	64	3,23	14	20	42,86
52,17	61,88	18,61	54	61	12,96	15	23	53,33
5,97	8,97	50,25	20	32	60,00	0	8	800,00
26,41	35,89	35,90	59	64	8,47	7	12	71,43
49,22	76,52	55,47	67	68	1,49	13	19	46,15
5,8	9,32	60,69	30	47	56,67	3	8	166,67
3,41	7,65	124,34	14	29	107,14	2	8	300,00
27,81	52,66	89,36	32	38	18,75	2	8	300,00
41,78	63,21	51,29	58	62	6,90	3	9	200,00
52,72	63,01	19,52	50	58	16,00	13	21	61,54
21,53	36,15	67,91	40	52	30,00	5	12	140,00
8,98	18,25	103,23	14	29	107,14	1	4	300,00
24,43	32,13	31,52	44	54	22,73	6	12	100,00
46,29	51,22	10,65	35	49	40,00	12	19	58,33
33,37	38,79	16,24	46	54	17,39	5	14	180,00
18,51	26,19	41,49	22	35	59,09	3	8	166,67
38,61	42,31	9,58	32	48	50,00	2	7	250,00
6,54	11,23	71,71	12	25	108,33	2	9	350,00
43,64	49,55	13,54	52	55	5,77	5	9	80,00
41,81	55,23	32,10	48	56	16,67	9	12	33,33
30,07	41,20	37,00	41,26	50,57	22,55	6,43	12,52	94,59
		11,13			9,30			6,09
16,18	20,18	30,80	16,55	13,02	33,87	5,00	5,66	167,54
0,00		24,78	0,00		-21,34	0,00		13,15
0,10	0,88		0,24	0,74		0,26	0,00	

8.9. Appendix 9: Turnitin Report

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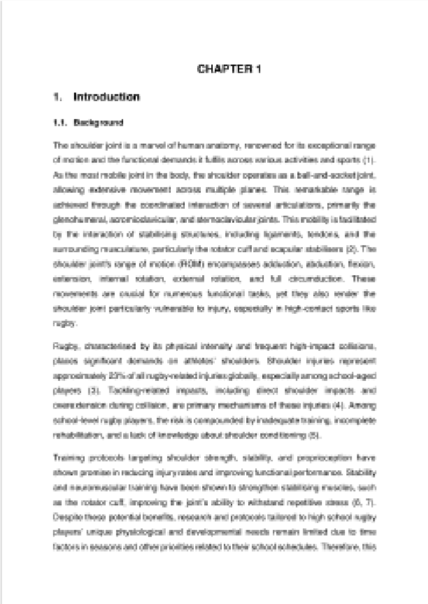

CHAPTER 1

1. Introduction

1.1. Background

The shoulder joint is a marvel of human anatomy, renowned for its exceptional range of motion and the functional demands it fulfils across various activities and sports (1). As the most mobile joint in the body, the shoulder operates as a ball-and-socket joint, allowing extensive movement across multiple planes. This remarkable range is achieved through the coordinated interaction of several articulations, primarily the glenohumeral, acromioclavicular, and sternoclavicular joints. This mobility is facilitated by the interaction of stabilising structures, including ligaments, tendons, and the surrounding musculature, particularly the rotator cuff and scapular stabilisers (2). The shoulder joint's range of motion (ROM) encompasses adduction, abduction, flexion, extension, internal rotation, external rotation, and full circumduction. These movements are crucial for numerous functional tasks, yet they also render the shoulder joint particularly vulnerable to injury, especially in high-contact sports like rugby.

Rugby, characterised by its physical intensity and frequent high-impact collisions, places significant demands on athletes' shoulders. Shoulder injuries represent approximately 20% of all rugby-related injuries globally, especially among school-aged players (3). Tackling-related impacts, including direct shoulder impacts and overextension during collision, are primary mechanisms of these injuries (4). Among school-level rugby players, the risk is compounded by inadequate training, incomplete rehabilitation, and a lack of knowledge about shoulder conditioning (5).

Training protocols targeting shoulder strength, stability, and proprioception have shown promise in reducing injury rates and improving functional performance. Stability and neuromuscular training have been shown to strengthen stabilising muscles, such as the rotator cuff, improving the joint's ability to withstand repetitive stress (6, 7). Despite these potential benefits, research and protocols tailored to high school rugby players' unique physiological and developmental needs remain limited due to time factors in seasons and other priorities related to their school schedules. Therefore, this