An investigation into the Anthropometric and Performance characteristics of Elite Female Gaelic football players.

Waterford Institute of Technology

Student Name: Molly Moran.

Student Number: 20072365

Supervising Lecturer: Emma Saunders.

Department of Submission: Health, Sport & Exercise Sciences.

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This project has been submitted in partial fulfilment of the Bachelor of Science (Honours) Degree in Sports Coaching and Performance.

I Confirm that all of the work submitted in this project is my own work, not copied from any other person's work (published or unpublished) and that it has not previously been submitted for assessment on any other course, in any other institution.

Molly Moran.

24th April 2019.

Abstract.

Background: The purpose of this study was to investigate and create a position-specific profile of anthropometric and performance characteristics of intercounty female Gaelic football players. This study aims to provide readers with normative data on said variables to assist with decision making in aspects of the game such as player selection, training methods and tactical influence.

Methods: Subsequent to ethical approval and signed consent to participate, thirty three (n=33) intercounty players were assessed in body mass (BM), stature, relaxed arm girth (RX), flexed arm girth (FX), calf girth (CG), bone breadth of humerus (BBH), bone breadth of femur (BBF), estimated percentage body fat (%BF), countermovement jump (CMJ), three repetition max (3RM), five meter acceleration (5M), twenty meter max speed sprint (20M) and an intermittent running test (Yo-YoIRT1). All anthropometric measures were assessed following ISAK guidelines and all results were presented as Mean ± SD [95% CI]. An ANOVA was used to determine any differences in results between positions.

Results: There was general similarity between players, possibly due to their common training programme and regime. Results for (Team means ± SD) arm girth (RX) (29.2 ± 1.21), arm girth (FX) (29.6 ± 1.13), CG (37.8 ±1.61), BBH (30.5 ± 0.96), 5M (0.9 ± 0.04), and 20M (3.0 ± 0.08) showed no significant differences when analysed according to playing position. However, forwards showed a significant difference in BM ($p \leq 0.026$) and height ($p < 0.001$) against midfielders. Backs showed significant differences in height ($p < 0.001$), BBF ($p \leq 0.042$) and Yo-YoIRT1 ($p \leq 0.047$) when compared to midfielders. Backs also showed significant differences in CMJ ($p \leq 0.021$), 3RM ($p \leq 0.048$) and Yo-YoIRT1 ($p \leq 0.047$) to forwards.

Conclusion: This normative data will be a useful resource to coaches of female Gaelic footballers when carrying out anthropometric and performance testing. This study will also help coaches to generate appropriate training regimes to maximise position-specific preparation for competition.

Key Words: female, Gaelic football, anthropometric, performance.

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1. Review of literature surrounding the anthropometric and performance characteristics of elite female Gaelic football players.

1.1 Introduction.

The female code of Gaelic football is a fast-paced, field-based sport, with demands for players to rely on their aerobic and anaerobic energy systems, learned-sport-specific performance characteristics and cognitive strengths, in a technical and tactical game setting (Shovlin et al., 2017; Martínez-Lagunas, Niessen, & Hartmann, 2014). To meet these sporting demands, coaches should strive to comprehend and seek to enhance in their players what anthropometric and performance characteristics their sport requires for players to compete at an elite level. With scientific literature to support coaching methods, elite players can then attempt to perform at optimal exertions and functioning capacity.

Anthropometry is the science of the traits that describe a person's body dimensions, with reference to height, body mass, body composition, lengths of limbs, breadths of bones and circumferences of areas (Fein et al., 2017). By coaches being aware of anthropometry and the advances in performance it can bring they can then, with the aid of this research, underpin the optimal sizes and proportions of elite athletes to perform exceptionally in Gaelic football. To compliment these findings, players can also be assessed of their performance characteristics to see if they not only show the physique of an elite athlete, but that they are also performing at elite standards. Accelerating, running at maximal speeds, decelerating, jumping and landing are, to name but a few, key performance characteristics in Gaelic football. It would, therefore, give rationale for coaches to understand, physiologically, what is occurring in the athletes to allow them to perform at optimum level. Both anthropometric and performance characteristics can, and have been, considered with respect to playing position, in team sports.

With minimal research published in the topics of anthropometrics and performance characteristics relating to elite female Gaelic football players, articles to support this literature review will be sourced from articles on the male code of Gaelic football with respect to anthropometric and performance characteristics and from articles on other team sports with similar demands to those of Gaelic football. Due to literature on male athletes supporting this review, it is imperative to consider gender physiological differences. Ideally, coaches should intend to expose athletes to training methodologies that they are going to get optimal adaptations from and have a high rate of transferrable execution once in a competitive setting. Literature reports differences in localised body composition between the sexes, but these differences tend to decrease if a comparison is made between those body parts under optimal sporting stress factors (Bishop et al., 1989). This indicates that significant differences will be found in literature when comparing anthropometrical characteristics between the sexes, however less significant differences will be found when performance characteristic outcomes are compared between male and female elite athletes. Thibault et al., (2010), showed that the gender gap in Olympic sport performance has been stable since 1983. These results within their study suggest that women's performances, even at the high level, will never match those of men and that even when performances still improve, these progressions are proportional for each gender. They also found that this stability is not affected by external, non-physiological factors such as technology and doping advancements that could challenge it, it is purely down to genetic make-up differences.

1.2 Anthropometric and Performance characteristics.

Gaelic football is a traditional past-time in Ireland, it is and has been, for many Irish citizens, a part of their culture and heritage (McIntyre, 2005). With traditions of the game being carried through generations, changes in practices are introduced with great difficulty. Talent identification for inter-county Gaelic football teams is carried out by trial days where players who are put forward by their coaches from many different teams within a county are called to a training ground and mock-competitive matches are played. This method is subjective and gives athletes an extremely short window to show their talent. Combining the current strategies with a day's testing of anthropometric and performance characteristics in athletes could create an objective way of identifying talent for inter-county teams. This has been used for Irish rowing athletes and has been a factor in athletes reaching a level of Olympic success.

In 2009, Wong and colleagues looked at the relationship between anthropometric and physiological characteristics in youth soccer players to provide coaches with a scientific-based rationale as to why coaches may or may not pick certain athletes for a position in the team. Did a goalkeeper achieve their position due to their measured standing height or because of their lower body power production? Or perhaps, was it the two variables combined? At a younger age, yes it was the anthropometric characteristics such as standing height that made them achieve their position, however, this can be a hinderance toward a player's performance development in later playing ages. It has been reported that soccer coaches select young players based on their anthropometric characteristics rather than their technical and tactical performances (Helsen et al., 2005; Vaeyens et al., 2005). Due to many studies finding positional differences, relating to anthropometric measurements and physiological performances, in team-based sports, evidence suggests that specific physiological demands and anthropometrical prerequisites exist for different playing positions and result in the selection of players based on superior physiological performances and anthropometrical advantage (Gil et al., 2007). While predispositions can be of positive influence in sporting careers for athletes, there are also flaws linked alongside them. Both the positive and negative influences of valuing predisposition can be viewed in short-term and long-term effects. Literature suggests that the long-term effect of such practice systematically excludes talented but late maturing players and eventually affects talent detection and identification procedure (Malina et al., 2000), negatively effecting a player's sporting career path from an early age because of prematurity bias. This bias would evidently only occur in youth athletes and it is suggested for coaches to consider psychological and sport-specific skills as opposed to the absolute anthropometric and physiological advantage in the selection of young athletes for developing future high-class players (Reilly et al., 2000). This literature review focused solely on multiple short-term effects of anthropometric and performance characteristics, of team sport athletes, such as determining playing position, elite characteristics versus non-elite and individualizing training prescriptions and methods.

1.3 Variables with respect to playing position.

In the game of Gaelic football, at any one time, there are fifteen individual playing positions that collectively make a team. Each of these positions hold different anthropometric and physiological demands determined by both the rules and aim of the sport but can, however, change due to tactical preferences (Collins et al., 2014). When a coach is conducting a battery of fitness tests for athlete monitoring it is important in a team setting to evaluate test results with respect to playing position and positional demands. Some research suggests that there are specific anthropometric characteristics of the players who play on different positions in the team (Bale, 1986; Rienzi et al., 2000; Gil et al., 2007). There is literature to support this across a multitude of sports, however, it is research on sports such as soccer, handball and rugby, that is much more extensive than that of Gaelic football.

Gjonbalaj, Georgiev & Bjelica (2018), when comparing anthropometric characteristics with respect to playing positions in U19 and U21 elite male soccer players, divided the sample into four groups: 20 goalkeepers (n = 20); 84 defenders (n = 84); 88 midfielders (n = 88) and 50 forwards (n = 50). They found that goalkeepers were significantly taller than outfield players, with little or no height difference between the three outfield positions: defenders; midfielders and attackers. While it was still within elite parameters, goalkeepers also showed to have the highest body fat percentage, followed by defenders, on the team. This difference to other positions was significant according to their study, however the absolute results suggest that all players, regardless of position, do similar or the exact same conditioning training.

Martinez-Lagunas et al. (2014) produced similar anthropometrical findings when they looked at the female player characteristics, with respect to playing positions in soccer. This study portrayed valid content throughout as the author mentioned the current anthropometrical and performance characteristic findings in many different countries, they also included that the findings would be of benefit to coaches for identification of individual physical strengths and weaknesses, evaluation of the effectiveness of a position-specific training program, setting individual and team physical fitness standards, talent identification and development (Svensson & Drust, 2005; Balsom, 1994).

Elite female handball players were found to follow similar positional anthropometrical characteristics to those of soccer players, however their upper body power and strength would surpass a soccer player, as scoring success in handball correlates significantly with throwing velocity (Chaouachi et al., 2009; Gorostiaga et al., 2006). This parameter could be influential to considerations of Gaelic football coaches as fielding the ball over-head (winning possession) and hand-passing (ball retention) are key performance indicators in the sport (McIntyre & Hall, 2005).

Two prevalent research articles on Gaelic football, by McIntyre et al. (2005) and Shovlin et al. (2017), highlight many conflicts to the papers a mentioned above regarding anthropometric findings. The tallest players on the pitch during a Gaelic football match, in the male code, are found to be midfielders and half-backs were found to be the most conditioned team members, with the lowest body fat percentages and quickest sprint performances over 5, 10 and 20 meters. This shows that, although the demands of Gaelic football and soccer have been researched to be similar (Reilly & Collins, 2008), positional anthropometrical and performance characteristic differences prevail with respect to sport-specific tactical influence.

1.4 Comparing elite and non-elite athletes.

There are constant controversial definitions appearing throughout research papers surrounding the term “elite”. During a systematic review, Swan et al., (2015), summarised the definition to eight broad categories: international and/or national level; experience; professionalism; training; involved in talent development; regional level; sport/ country-specific measures and finally university. Each study in this literature review fits into one or more of those eight categories, however, in relation to Gaelic football national or inter-county level athletes would be the most suitable and appropriate definitive of elite.

Success in sports is directly related to the specific anthropometric characteristics, body composition and somatotype components (Carter & Heath, 1990). It is believed that the physical demands of the game become more pronounced as the level of competition increases (Reilly, 1994). Thus, football players independent of their gender need to achieve a reasonable balance in developing these physiological and physical capacities that is appropriate to the level they compete at and their positional role (Svensson, 2005).

In a study comparing elite and non-elite athletes from five different activities or sporting backgrounds, it was concluded that elite athletes measured taller in height, were faster on a 20m sprint and both their upper and lower body power, in a medicine ball throw test and a standing long jump test respectively, was significantly greater within this cohort of female volleyball players (Milić et al., 2017). When comparing elite and sub-elite junior rugby players, the elite athletes tested significantly superior to their sub-elite counterparts in many anthropometric and performance parameters. The elite group were, again, taller; faster over 10, 20 and 40m sprints; more conditioned, showing lower body fat percentages; were able to produce a higher peak power output in a vertical jump test and were significantly more agile than the sub-elite group during the 505 Test (Gabbett et al., 2009). Although the sub-elite group was labelled as “sub-elite”, the cohort showed greater playing experience to their elite cohort of athletes. This poses conflict to the definition of elite and to the hypotheses of studies in other sports. It may be suggestive of coaching exposure the athletes received throughout their playing career.

It is evident that within an array of sports that both anthropometric and performance characteristics correlate and that they show significantly demanding results when considering elite athletes.

1.5 Comparing elite athletes with respect to starters and non-starters.

Despite the importance of one's physical qualities to their playing standard, physical fitness tests also have the ability to predict team selection (Gabbett et al., 2009; Young et al., 2005). In conjunction with that, Hasan et al., (2007), found that anthropometric characteristics and body composition can influence the selection of athletes in many sports. Black et al., in 2017, completed the first study to investigate the influence of physical qualities on team selection and activity profiles in female Australian Football match play. The findings demonstrated that players who are faster and have greater intermittent running ability are more likely to be selected and that midfielders perform more activity during match play than half- and full-line players. Portrayed in the results of this study was that starting players were taller, had gained more playing experience, had a greater training age and a larger body mass, however, this result did not differentiate between fat-mass and or muscle-mass.

In the same study, mentioned above, by Gabbett et al., (2009) also compared junior rugby starters and non-starters in both groups of elite players and sub-elite players. While the elite were out-performing the sub-elite group, the elite starters were out-performing all other sample-groups in anthropometric and physiological tests. Interestingly though, the sub-elite starters were taller and had a greater body mass than the elite starters group. The sub-elite starters also performed to the same level of excellence during the 505-agility test. Lastly, the greatest estimated Vo2max from the sub-elite starters group was significantly greater than that of the counterpart in elite non-starters group. All of the results mentioned were proven in this study to have influenced coaches during player selection for the team.

1.6 Training Individualization.

Out of all of the studies in this review of literature surrounding the anthropometric and performance or physiological characteristics, all authors concluded their findings that by assessing these parameters it facilitates the prescription and individualized or positional-specific training programs for team-based sports (Higham et al., 2013; Milíc et al., 2017; Shovlin et al., 2017; Mala et al., 2015; Martín-Matillas et al., 2014 & Martínez-Lagunas et al., 2014). Facilitation of this hypothesis is yet to be introduced to teams' training methods as limitations of this suggest it may be too time-consuming or it could possibly create a negative effect toward team-cohesion and that individualized training methods may not transfer fluidly onto the pitch or court. However, it is evident within the many studies in this review that different positions on a team require different demands and thus, the most important thing coaches can take from that scientific evidence is that players are exposed to each of those demands within their training, whether it be specific to their individual position or not.

1.7 Summary and Rationale.

It is clear within the research that the two variables, anthropometrics and performance characteristics, differ with respect to elite athletes and non-elite athletes, starters and non-starters and also playing position, in many team-based sports. However, there is an evident flaw in the literature. If researchers are testing these parameters and finding positional differences, then the industry is victim to a poor scientific-based research to practical application transfer strategy, as there is minimal evidence of training individualization. The idea if favoured by researchers, but not yet implemented by coaches. It is arguable that it is time consuming and subject to frequent change, however, similar to the physical and physiological demands and other demands of sport, this may be a coaching demand and a marginal gain in performance.

Finally, the rationale for this research paper, supported by this literature review, is that there was no research in the area of anthropometric and performance characteristics for elite female Gaelic football players. Traditional demands of the game are constantly being surpassed, perhaps due to the evolution of coaching methods, without little or no scientific-based evidence to support or further, the evolving changes and increases in performances. In the circumstances for this study, results were based off thirty-one (n=31) elite female Gaelic football players, however, due to it being the first in the area, reliability of results were automatically reduced as performance outcome on testing days of players is subjective to many factors relating to their personal and work-lives. Therefore, by it being a positive step in the right direction for scientific support to elite female Gaelic footballers and their coaches, the area of research has potential to be repeated on similar cohorts, to increase reliability and validity of testing results.

2. Research Questions.

- What are the typical values, per position, for body mass, height, limb girths and bone breadths in elite female Gaelic football players?
- What are the typical values, per position, for performance characteristics in elite female Gaelic football players?
- What are the typical values, per position, for skinfold thickness (individual and sum) in elite female Gaelic football players?

- What are the typical values, per position, for %BF in elite female Gaelic football players?
- Do anthropometric characteristics, in female Gaelic football players, differ significantly with respect to playing position?
- Do performance characteristics, in female Gaelic football players, differ significantly with respect to playing position?

3. Methodology.

3.1 Conceptual Framework.

This descriptive style research paper was supported by quantitative findings to display to readers the anthropometric and performance characteristics that help to meet a player's demands in the female code of Gaelic football, with respect to their playing position. A convenience sample of elite players were used to collect the quantitative and descriptive data reported below during the team's pre-season training. Ethical approval for this study was granted by the ethics committee of the Department of Health, Sport and Exercise Sciences in Waterford Institute of Technology.

3.2 Data Sources.

The participants measured and tested in this research article were an elite, inter-county female Gaelic football team, from which the researcher gained access to through their internship and ongoing background staff participation. The cohort included both starting players and substitute players, aged between 18 years and 30 years of age.

Inclusion criteria were: (1) Players had to be 18 years +, (2) Had to have two years experience at intercounty level. Exclusion criteria were: (1) Players could not be injured at the time of testing, (2) Players between day 21 and day 28 of their menstrual cycle on testing days could also not participate.

Due to testing being on separate days, times and date were arranged between the researcher, the coach and the cohort, with anthropometric measurements taking place in the morning before the consumption of a main meal. All documents supporting this study were primary articles sourced from Academic Search Complete and Waterford Institute of Technology Library online search engines around field and or court-based female athlete anthropometrics and performance characteristics regarding the demands of their relevant sports.

3.3 Data Collection Variables and Procedures.

3.3.1 Anthropometric Variables.

Variables measured under Anthropometry included: Body mass; Height; Arm Girth (relaxed); Arm Girth (flexed); Calf Girth; Bone Breadth (humerus); Bone Breadth (femur) and Skinfold thickness. All measurements were taken at 9am GMT, before the participants consumed their first meal of the day. All participants were provided with information and consent forms prior to testing days (Appendix A, B, C &D).

Body mass & Height.

Body mass was assessed with a portable digital weighing scales (Soenhle Style Comfort 400 Digital) results were recorded to the nearest 0.1kg. Participants were advised to wear minimal clothing, thermal shorts, a sports bra and to remove their footwear to obtain accurate results. Height was assessed using a portable stadiometer (Seca Freestanding Mobile Stadiometer) results were recorded to the nearest 0.1cm and again, participants removed their footwear for this test for accuracy and reliability.

Limb Girths.

Arm girth relaxed and flexed, and calf girth were all measured following ISAK guidelines (Stewart et al., 2011) (Appendix E). A standard fibreglass measuring tape was used to take measurements and results were recorded at the nearest 0.1cm.

Bone Breadths.

Bone breadths (humerus and femur) were measured following ISAK procedures (Stewart et al., 2011) using a bone callipers (AvaNutri Small Bone Anthropometer Callipers) results were recorded at the nearest 0.1mm. For these tests participant's measurements were taken from bare skin to ensure validity of results.

Skinfold thickness.

Skinfold thickness was taken from 8 sites from each participant: Bicep; Tricep; Subscapular; Supraspinale; Iliac Crest; Abdominal; Thigh and Calf, each on the right side of the body for standardisation of results. Results were recorded at the nearest 0.1mm and ISAK guidelines were followed to take each measurement (Stewart et al., 2011) (Appendix F). Participants wore minimal clothing for gathering of this data to ensure no interference with individual site measurements. Individual sites were measured and both the sum of seven sites ($\sum$ 7SKF) (Tricep + Subscapular + Bicep + Supraspinale +

Abdominal + Thigh + Calf) and the sum of eight sites (∑ 8SKF) (previous list + iliac crest) were calculated to be converted into percentages using the Yuhasz (Yuhasz et al, 1962) ([0.1051*∑7SKF]+2.585) and Withers (Withers et al, 1982) [495/(1.0988-0.0004*∑8SKF)-450] equations respectively, to be then used for analysis.

3.3.2 Performance Variables.

Performance variables that were tested included: A Counter-Movement Jump Test (CMJ); Three Repetition Max Strength Test (3RM); 5-meter Acceleration Test (5m); a 20-meter Maximum Speed Sprint Test (20m) and an Aerobic Endurance Test (Yo-YoIRT1). Testing took place at 7pm GMT, six days post anthropometric testing, in the above order, to allow participants to be fully fuelled and hydrated for maximal testing.

Counter-Movement Jump Test.

The Counter-Movement Jump was assessed using a contact mat (Chronojump Contact platform kit DIN-A1). Participants were instructed to wear performance runners and performance permitting clothing (Shorts and t-shirt). Participants obtained a hip-width distance stance with their hands placed on their hips before jumping for a standardized approach (Markovic et al., 2004). The test was performed following a "3,2,1" countdown from the researcher and each participant was given two attempts. The best result from two attempts was noted and results were recorded to the nearest 0.1cm.

Three Repetition Max Strength Test.

A Hex-Bar bent-knee deadlift exercise was executed by participants for three maximal repetitions to display results for this test. This method of this exercise ensures safety when lifting and an estimate of each participants one repetition max can be calculated from this result (3RM*1.08 =1RM) (Baker, D. 2001). Participants were informed of the need to not train the muscles (or antagonists) to be assigned testing on a given day for at least 48 hours prior to the scheduled session (Reynolds et al., 2006). Protocol followed the programme see Appendix G. The warm-up set and set one at different loads allow for muscle activation and potentiation in the same movement patterns as the maximal lift set, set two (Young, W., 1993).

Aerobic Endurance Yo-Yo Intermittent Running Test Type 1.

The Yo-YoIRT1 (Bangsbo et al., 2008) was performed in the arena in Dublin City University, Sports Campus, on a wooden sprung floor sports hall. The test was set up as per Appendix H. Participants were instructed to wear performance running shoes and performance permitting clothing and encouraged to remain in the test for as long as they were physically capable. The test was conducted via Bluetooth audio speaker (Philips BM6 636).

5-Meter Acceleration Test.

Acceleration capabilities of the cohort over 5-meters (Lockie et al., 2011) was tested in the same arena hall as the Yo-YoIRT1 test following a 10-15-minute recovery for participants. Results were recorded using Brower Timing Systems timing gates. Participants were instructed to complete the test from a static start, given two attempts which the researcher recorded their best time at the nearest 0.1sec. Timing gates were placed at 0m and 5m and operated off a beam system, they were set at their minimum height of 35cm ensuring the beam was only broken by participant's lower extremities, which prevented false readings.

20-Meter Maximum Speed Sprint Test.

Using the Brower Timing System timing gates again, participants performed a 20-meter sprint test twice over and their best result at the nearest 0.1sec was recorded by the researcher. The test was performed from a 10-meter flying start (Haugen et al., 2012) and gates were placed at 0m and 20m, again at the height of 35cm.

3.4 Data Analysis.

All data was reported as a means and standard deviation (means ± SD) unless stated. Data was calculated for all players with respect of positional group, with 95% conference intervals. All data was tested for normality and all data that did not pass tests was removed from statistical analysis. A univariate analysis of variance (ANOVA) along with a Tukey (HSD) post hoc test were performed to determine if there was variation in position (dependent variable) present within any of the anthropometric and performance characteristics (independent variables), statistical significance was set at <0.05. All statistical analysis was performed using Jeffrey's Amazing Statistics Program (JASP) as it produced APA style referencing results.

3.6 Ethical Considerations

All participants in this study received a hard copy document outlining the content and procedures of the study and testing, along with an informed consent form that they signed stating they understood the terms and conditions of the process and that participants were of the knowledge that they could withdraw from the study at any time without penalty. All participants were 18 years or over and had a training age of, minimum, two years at inter-county elite level. The cohort members were identified numerically during data collection to ensure they remained anonymous throughout. Their signature showed consent to take part and that data remained anonymous, was used for the sole purpose of the study and was only in possession of the researcher and student advisor. All data was destroyed post-study.

4. Results

4.1 Anthropometric Characteristics.

Thirty-one elite female Gaelic football players participated in this study representing the outfield positions of backs (n=11), midfields (n=4) and forwards (n=16). Anthropometrics measurements including: body mass; height; arm girth (relaxed); arm girth (flexed); calf girth; bone breadth (humerus) and bone breadth (femur) are presented in Table 1. Body mass is displayed in kilograms and all other variables in centimetres.

A significant difference in body mass was found between forwards and midfields, with midfield players being typically heavier. A difference of significance in height was found between both backs and forwards against midfields, with midfield players presenting to be the tallest players on the pitch.

Table 1 Anthropometric Measurements.

	Backs (n= 11)	**Midfields** (n= 4)	**Forwards** (n= 16)
Body Mass	66.64 ± 2.7 [62.8-71]	69 ± 1.67 [66.8-70.4]	63.92 ± 4.2[a] [59.4-72.6]
Height	163.2 ± 2[b] [160-166]	173 ± 3.43 [169-177.1]	164.9 ± 3.53⊠ [159-171]
Arm Girth (R) relaxed	29.20 ± 1.28 [26.5-31.2]	28.13 ± 0.62 [28.2-29.7]	29.27 ± 1.36 [26.7-31.1]
Arm Girth (R) flexed	29.61 ± 1.1 [27.3-31.3]	29.7 ± 0.88 [28.5-30.5]	29.77 ± 1.27 [27.9-32]
Calf Girth (R)	38.23 ± 1.84 [36-41.6]	37.85 ± 1.96 [35.1-39.4]	37.48 ± 1.44 [35.5-41.5]
Bone Breadth Humerus	31.05 ± 0.61 [30.2-32]	29.85 ± 0.69 [29.3-30.8]	30.37 ± 1.1 [28.9-32.1]
Bone Breadth Femur	63.44 ± 1.08[d] [61.8-65.2]	61.3 ± 1.38 [60.3-63.3]	62.71 ± 1.55 [30.1-65.6]

Data presented as Mean ± SD [95% CI]. [a]$p \leq 0.026$ significantly different to midfields. [b]$p < 0.001$ significantly different to midfields. [c]$p \leq 0.001$ significantly different to midfields. [d]$p \leq 0.042$ significantly different to midfields. Abbreviations: (R), right-hand side of body.

Table 2 presents the individual site measurements, in millimetres, of body fat per position by mean ± standard deviation, including maximum and minimum values. There was no significant difference in any of the eight sites between positions, tricep (F=0.947, p=0.4), subscapular (F=0.098, p=0.907), bicep (F=3.210, p=0.056), iliac crest (F=0.394, p=0.678), supraspinale (F=0.612, p=0.549), abdominal (F=0.121, p=0.887), thigh (F=0.064, p=0.938) and calf (F=1.098, p=0.347). The lowest skinfold measurements for the majority of the 8 sites were within the forwards. Backs and Midfields showed the highest skinfold measurements for the same number of sites.

Table 2 Skinfold thickness per site.

Position	Tricep (mm)	Subscapular (mm)	Bicep (mm)	Iliac Crest (mm)	Supraspinale (mm)	Abdominal (mm)	Thigh (mm)	Calf (mm)
Back	16.14 ± 3.1 [11.6-22.8]	9.9 ± 1.5 [8.4-13.6]	8.1 ± 2 [5.4-12.2]	14.7 ± 4.9 [6.1-23.2]	7.4 ± 1.6 [4.4-9.6]	15.4 ± 3.8 [7.4-20.6]	27.5 ± 6.2 [14.6-38.2]	14.6 ± 6.3 [9.2-29.2]
Midfield	14 ± 3.4 [11.4-18.8]	9.5 ± 3.4 [7.2-14.6]	5.8 ± 1.8 [4.4-8.4]	12 ± 3.4 [7.8-15.2]	7.2 ± 1.9 [5.6-9.8]	15.3 ± 5.2 [9.4-21.2]	26.6 ± 12.6 [16.4-43]	10.8 ± 5.7 [6.6-19]
Forward	16.8 ± 3.9 [9.4-22]	10 ± 2.3 [6.7-15.4]	7 ± 1.7 [4.8-10]	14.1 ± 5.5 [5.5-28.4]	8.3 ± 2.7 [4.6-16.2]	14.9 ± 5.3 [7.2-28.4]	28.1 ± 7.4 [16.2-40]	12.5 ± 3.9 [5.8-18.4]

Data presented as Mean ± SD [95% CI]. Abbreviations: mm, millimetres.

Comparison of the fat patterns according to mean skinfold thickness measures further highlight the variability in fat distribution between individual sites per position. This is demonstrated in the skinfold radar charts for each position in Figure 1.

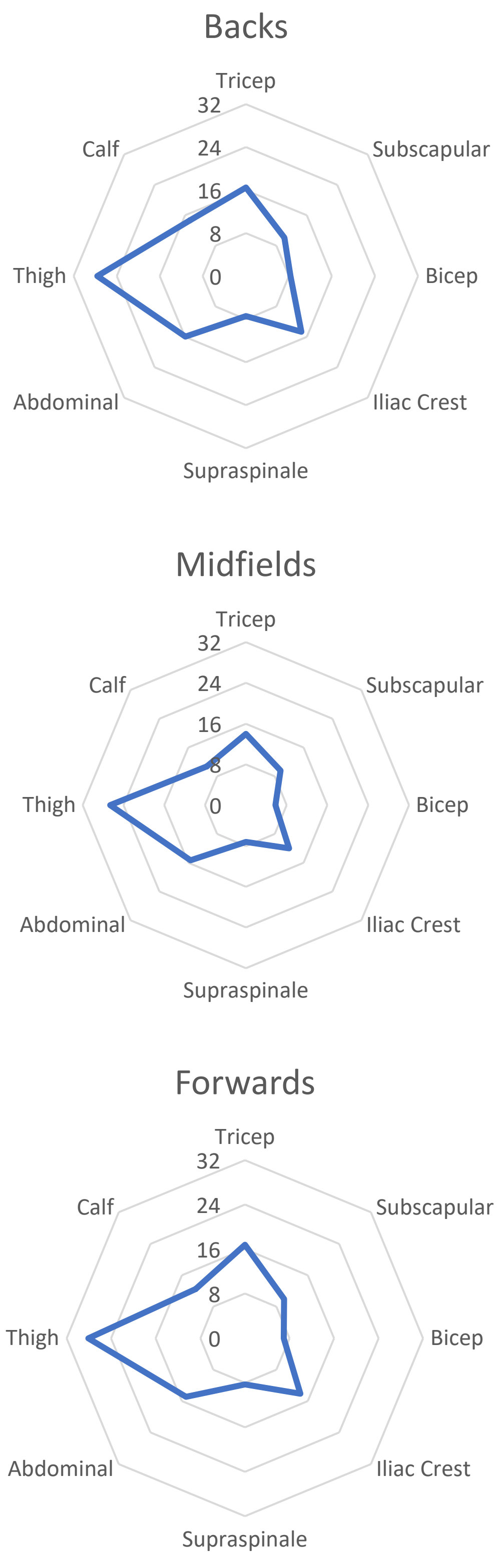

Figure 1 Radar map of skinfold sites per position

Table 3 shows the mean ∑8SKF ± standard deviation with minimum and maximum values and the mean ∑7SKF ± standard deviation with minimum and maximum values. No significant difference was found between positions using either the Withers' equation (F=0.555, p=0.580) or the Yuhasz's equation (F=0.515, p=0.603). The range for %BF using the Withers et al. (1987) equation for positions were: backs 16.4% to 27%, midfields 15.6% to 21.1% and forwards 10.9% to 28.3%. The range for %BF using the Yuhasz et al. (1962) equation for positions were: backs 12.4% to 18.6%, midfields 12% to 15.2% and forwards 9.1% to 19.4%.

Table 3 Estimated %BF per position using two different equations.

Equation	**Backs (%)** (n= 11)	**Midfields (%)** (n= 4)	**Forwards (%)** (n= 16)
Withers % BF (Withers et al, 1987)	19.9 ± 3.1 [16.4-27]	17.8 ± 2.4 [15.6-21.1]	19.6 ± 4.6 [10.9-28.3]
Yuhasz % BF (Yuhasz et al, 1962)	14.7 ± 2 [12.4-18.6]	13.2 ± 1.4 [12-15.2]	14.3 ± 2.7 [9.1-19.4]

Data presented as Mean ± SD [95% CI]. Abbreviations: BF, body fat.

4.2 Performance Characteristics.

Below in Table 4 results of participant's countermovement jumps, three repetition maximum lifts and yo-yo intermittent running test are displayed per position. Countermovement jump results are displayed in centimetres. 3RM results are displayed in kilograms. Yo-YoIRT1 results are displayed in meters. Backs showed significantly lower jump heights compared to forwards in the CMJ.

Table 4 Performance Characteristics (full cohort) per position.

	Backs (n=11)	**Midfields** (n= 4)	**Forwards** (n= 16)
CMJ	34.62 ± 3.6^{a} [27.1-40]	32.55 ± 2.6 [29.2-35.4]	38.1 ± 4.6 [29.9-46.2]
3RM	84.4 ± 11.8^{b} [50-93]	95 ± 5.8 [90-100]	94.8 ± 11.8 [80-115]
Yo-Yo IRT1	728.3 ± 178☒^{d} [480-1000]	1005 ± 116 [880-1160]	909 ± 262 [480-1360]

Data presented as Mean ± SD [95% CI]. $^{a}p \leq 0.021$ significantly different to forwards. $^{b}p \leq 0.048$ significantly different to forwards. $^{c}p \leq 0.047$ significantly different to forwards. $^{d}p \leq 0.047$ significantly different to midfields. Abbreviations: CMJ, countermovement jump; 3RM, three repetition maximum; IRT1, intermittent running test one.

Table 5 highlights the mean sprint times over 5 and 20 meters ± standard deviations including maximum and minimum sprint times per position. No significant differences were reported between positions over 5-meters ($F=0.066$, $p=0.936$) or over 20-meters ($F=1.649$, $p=0.214$). Results are displayed in seconds with ranges of results over 5-meters for the population from 0.86 seconds to 1.0 seconds and over 20-meters, for the population, from 2.85 seconds to 3.15 seconds.

Table 5 Performance Characteristics (partial cohort) per position.

	Backs (n= 9)	**Midfields** (n= 3)	**Forwards** (n= 14)
5m Acceleration	0.95 ± 0.05 [0.86-0.99]	0.95 ± 0.04 [0.9-0.98]	0.94 ± 0.04 [0.88-1.0]
20m Max. Speed	3.02 ± 0.05 [2.98-3.11]	3.01 ± 0.06 [2.96-3.08]	2.97 ± 0.09 [2.85-3.15]

Data presented as Mean ± SD [95% CI]. Abbreviations: Xm, meters; Max., maximum.

5. Discussion.

This is the first study to investigate and describe the anthropometric and performance characteristics of elite female Gaelic football players. The purpose of this study was to create a profile and compare between positions, the variables of anthropometric and performance characteristics within elite female Gaelic football players. The elite cohort (Mallett & Hanrahan, 2004) involved in this study were the most successful team leading up to, during and post data collection for this study therefore, the findings presented will help coaches to determine which anthropometric and or performance qualities in female athletes may enhance or hinder overall competitive performance. All results presented will also provide coaches and or readers with an understanding of sporting demands and practical applications for Lady’s Gaelic football.

It was hypothesized that midfielders would be the tallest outfield players on the team and along with backs, be the most conditioned players on the pitch, with the lowest estimated percentage body fat (McIntyre et al., 2005; Shovlin et al., 2017). While this study found no significant differences in estimated percentage body fats between positions, midfielders did prove to be taller than backs and significantly taller than the forwards in this cohort. The results seen in Table 1 show no significant differences in arm girth (RX), arm girth (FX) or BBH between positions, however the radar diagrams presented in Figure 1 depict that backs carry a higher percentage of their body fat in their upper extremities (bicep, tricep and subscapular) and also measured highest on the calf site too.

So, while no significant difference was found between positions, the results did oppose the hypothesis that backs would be some of the most conditioned players with estimates of the lowest %BF. Gjonbalaj, Georgiev & Bjelica (2018), challenged this hypothesis in their study stating that U19 and U21 elite male soccer players playing in a defending position had accumulated the second highest %BF between positions. Their study concluded that players of all positions be exposed to identical conditioning training. The finding that backs carry the highest percentage of %BF in their upper extremities of all three positions relates somewhat to the findings of Chaouachi et al. (2009) and Gorostiaga et al. (2006) that female handball players have significant upper body strength and throwing velocity capacities, because a similar action in Gaelic football is aerial play, catching overhead to gain possession, but typically for backs they wouldn't feature as often as midfielders or forwards in aerial battles. Therefore, this disagreement of hypotheses may derive from technical influences and game-conditions.

The findings in Table 2 also have great influences on results presented in Table 3. Both the Withers (1987) and the Yuhasz (1962) equations were used to estimate positional means for %BF, the Yuhasz equation is a seven-site equation omitting the skinfold thickness of the iliac crest, thus, reducing players estimated overall body fat percentage significantly in some cases. This is important to highlight to coaches and to educate them on which equation will tell them necessary information about their athlete should they decide to test skinfolds and proceed to develop conditioning regimes based on results.

For many athletes in this squad, the position they were tested under for the purpose of this study is the position they would have played in for the majority of their Gaelic football career. With that considered, performance and or results may have been influenced by exposure of repetitive position-specific stimuli throughout their playing experience. This hypothesis supports the findings seen in Table 4. McIntyre et al. (2005) reported on the positional demands of Gaelic football and the disparity between positions in intercounty game settings. The CMJ, 3RM and Yo-YoIRT1 all tested athletes in varying game demands such as jumping, landing, strength and aerobic endurance, including too, psychological factors however they were not recorded for this study. Aerobic demands within Gaelic football are enforced heavily on midfield players and so it would be assumed they would have the greatest distance covered in the Yo-YoIRT1, this is displayed in Table 4.

Finally, for all results showing no significant differences for example the 5M and 20M sprints, it is imperative to consider that this entire cohort were training under the same programmes, intensities and modalities irrespective of position. This underpinning fact instils the cause for little or no significance between positions in various tests throughout this study and that previous research identifies with similar significant findings to those presented in this study.

5.1 Limitations of the Study.

Due to the specific inclusion criteria within anthropometric and performance testing on female athletes, the entire team cohort were not eligible to participate. One back (n=1) was excluded from the data set as she was injured at the time of testing and results were not normative due to hindered performance. The team's goalkeeper was present during testing, however with the sample for that position accumulating to one (n=1) results would have held no solid value and could not be considered normative. Two backs (n=2), one midfield (n=1) and two forwards (n=2) were excluded from performance testing (CMJ, 3RM, Yo-YoIRT1, 5M and 20M) and data due to demand from their university Gaelic football team commitments. They were absent on the day of performance testing but were still included within the anthropometric testing data as they were present and met the inclusion criteria. The results presented may offer normative results of anthropometric and performance characteristics for readers, but this study only presents the results of one elite female Gaelic team and should be interpreted accordingly. A standardised battery of anthropometric and performance tests conducted with larger sample sizes, over a number of seasons with multiple teams will provide further insight regarding the normative profile of a player per position.

5.2 Practical Applications.

While anthropometric characteristics are not the sole indicator of athletic performance they are identified as an essential component (Thomas et al., 2016). Similarly, the ability within athletes to execute a performance test is a key indicator of athletic ability, particularly if the test is relative to the sport, however, data collected by coaches should only influence future practice and not dictate future practice. It is favourable that players are meeting the normative data values applicable to them and their positional demands, but once these qualities are met, the ability to execute Gaelic specific skills under pressure and in game conditions provides greater feedback to coaches than any environmentally abnormal test will.

6. Conclusion.

In summary, this was the first study to profile the anthropometric and performance characteristics per position of an elite female Gaelic football team providing readers with normative data. This study has differentiated, between outfield positions in Gaelic football, normative data on said characteristics which may encourage coaches to plan performance enhancing training sessions or conditioning sessions in attempt to train teams to meet elite playing standards. With that, the results in this study showed disparity between backs, midfields and forwards in varying tests, therefore showing players in different positions reach different demands, therefore making it support the hypothesis is position-specific training regimes and or programmes.

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Appendices.

Appendix A: Plain language overview of study.

Appendix B: Participant information and invitation form.

Appendix C: Informed consent form.

Appendix D: Data recording testing sheet.

Appendix E: ISAK assessment for limb girths

Appendix F: ISAK assessment for skinfold thickness

Appendix G: Programme for 3RM test

Appendix H: Test design for Yo-YoIRT1

Appendix A: A plain language overview of study.

Anthropometric and performance characteristics of elite female Gaelic football players.

This is a descriptive type study (so no pre and post testing) with results highlighting the anthropometric and performance characteristics obtained and maintained by elite female G.A.A athletes, to deem them "*elite*".

Testing: Preferably, athletes are tested on two separate days – Day 1 Anthropometric measurements. Athletes should be tested in the morning, fasted for max. 12 hours, but hydrated (i.e min 1L water consumption).

Day 2 Performance testing. CMJs, followed by 3RM, then a Yo-YoIRT1, a 5m Acceleration Sprint test and finally a 20m Maximum Speed Sprint test. These tests can take place at any time of the day, as long as athletes are fuelled (have eaten and are hydrated).

Their commitment level required is two days, tying in with their own availability (I will strive to suit them, time wise). Best practise for testing of Day 1 elements would be arranging, via email with me, a 15min appointment to get all measurements done as they are a one-on-one process. For Day 2, all participants can arrive together.

Finally, the purpose of this study is:

- To see significant differences between positions in both anthropometric and performance characteristics.
- Highlight to readers the demands required by elite female Gaelic football players.
- Possible, future, introduction of training or conditioning programs per position (semi-individualization).

Appendix B: Participant information and invitation form.

Information Form.

You are invited to take part in an Undergraduate dissertation study surrounding the anthropometric and performance characteristics of elite female Gaelic football players. The purpose of this study is to highlight the anthropometrical and performance demands elite players are meeting in the modern game. As a participant you must be willing to undergo the following tests:

Anthropometrics	Performance
Body Mass	Counter Movement Jump
Height	3 Repetition Max Deadlift
Sitting Height	Running-based Anaerobic Sprint Test
Arm Span	Yo-Yo Intermittent Running Test (1)
Bone Breadths & Limb Girths	
Body Composition	

Participants in the study must have a minimum of 2 years playing experience with the Dublin Senior Ladies football team and be 18+ years of age. Any participants with a chronic and or acute lower limb injury will be unable to take part in the study, similarly, participants with days 21-28 of their menstrual cycle will be excluded. Participants will be numerically identified to ensure anonymity.

Note: There is a risk of injury which consists of, but is not limited to, muscular, tendon, joint and bone injury. If you have any complaints, please do not hesitate to contact the following:

Researcher: Molly Moran

Researcher's contact details: 0862244672 mollymoran05@gmail.com

Researcher's Supervisor: Emma Saunders

Supervisor's contact details: ESAUNDERS@wit.ie

Appendix C: Informed consent form.

Informed Consent.

Anthropometric and performance characteristics of elite female Gaelic football players.

Researcher: Molly Moran.

Researcher contact details: 0862244672

Mollymoran05@gmail.com

Please confirm that you have read and understood the information sheet above for this study and have had the opportunity to ask questions to the researcher, that your participation is voluntary, and withdrawal is optional at any stage of the study and does not welcome penalty and finally, that you would like to take part in the study by signing below:

Participant's name (BLOCK CAPITALS: ________________________________

Participant's mobile (optional): ________________________________

Participant's email: ________________________________

Participant's signature: ________________________________

(DD/MM/YYYY) _____/_____/_____

Appendix D: Data recording testing sheet.

TESTING SHEET

Participant #: ______________________________

Participant Name: ______________________________

Participant D.O.B: ____/____/____

Participant Playing Position: ______________________________

Results.

Body mass (weight kg)	
Height	
Sitting height	
Arm span	
Bicep (mm)	
Tricep (mm)	
Subscapular (mm)	
Supraspinale (mm)	
Suprailac (mm)	
Abdominal (mm)	
Thigh (mm)	
Calf (mm)	
Girth – Arm (R) (R)	
Girth – Arm (R) (F)	
Girth – Thigh (R)	
Girth – Calf (R)	
Bone Breadth – Humerus (R)	
Bone Breadth – Femur (R)	
Counter Movement Jump	
3 RM Deadlift	
Yo-Yo IRT 1	
RAST	

Appendix E: ISAK assessment for limb girths.

Arm

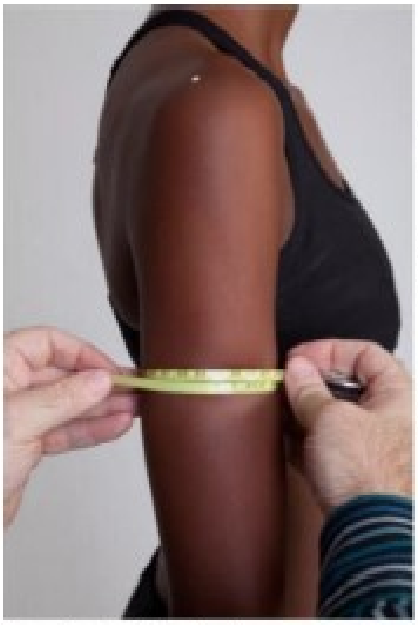


Figure 51: Arm girth relaxed

15 Arm relaxed®

Definition: The circumference of the arm at the level of the Mid-acromialeradiale® site, perpendicular to the long axis of the arm.

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides. The subject's right arm is abducted slightly to allow the tape to be passed around the arm.

Method: Once the cross-taped position has been achieved, the tape should be aligned so that the mid-acromiale-radiale landmark is situated centrally between the two parts of the tape.

Appendix F: ISAK assessment for skinfold thickness.

Acromiale®

Definition: The point on the superior aspect of the most lateral part of the acromion border.

Subject position: The subject assumes a relaxed position with the arm hanging by the side. The shoulder girdle should be in a mid-position.

Location: Standing behind and on the right hand side of the subject, palpate along the spine of the scapula to the corner of the acromion. This represents the start of the lateral border which usually runs anteriorly, slightly superiorly and medially. Apply the straight edge of a pencil to the lateral and superior margin of the acromion to confirm the location of the most lateral part of the border. Mark this most lateral aspect. The acromion has an associated bone thickness. Palpate superiorly to the top margin of the acromion border in line with the most lateral aspect.

Radiale®

Definition: The point at the proximal and lateral border of the head of the radius.

Subject position: The subject assumes a relaxed position with the arm hanging by the side and the hand in the mid-prone position.

Location: Palpate downward into the lateral dimple of the right elbow. It should be possible to feel the space between the capitulum of the humerus and the head of the radius. Then move the thumb distally onto the most lateral part of the proximal radial head. Mark with a short line perpendicular to the long axis of the forearm. Correct location can be checked by slight rotation of the forearm which causes the head of the radius to rotate.

Mid-acromiale-radiale®

Definition: The mid-point of the straight line joining the Acromiale® and the Radiale®.

Subject position: The subject assumes a relaxed position with the arms hanging by the sides.

Location: Measure the linear distance between the Acromiale® and Radiale® landmarks with the arm relaxed and extended by the side. The best way to measure this is with a segmometer or large sliding caliper. If a tape must be used, be sure to hold it so that the perpendicular distance between the two landmarks is measured, rather than following the curvature of the skin. Place a small mark at the level of the mid-point between these two landmarks. Project this mark around to the posterior and anterior surfaces of the arm as a horizontal line. This is required for locating the Triceps® and Biceps® skinfold sites.

Triceps skinfold site®

Definition: The point on the posterior surface of the arm, in the mid-line, at the level of the marked Mid-acromiale-radiale® landmark.

Subject position: The subject assumes a relaxed standing position with the arm hanging by the side and the hand in the mid-prone position, i.e. with the thumbs pointing forward.

Location: This point is located by projecting the Mid-acromiale-radiale® site perpendicularly to the long axis of the arm around to the posterior surface of the arm, and intersecting the projected line with a vertical line in the middle of the arm when viewed from behind.

Biceps skinfold site®

Definition: The point on the anterior surface of the arm at the level of the Mid-acromiale-radiale® landmark, in the middle of the muscle belly.

Subject position: The subject assumes a relaxed standing position with the arm hanging by the side and the hand in the mid-prone position, i.e. with the thumb pointing forward.

Location: This point can be located by projecting the Mid-acromiale-radiale® site perpendicularly to the long axis of the arm around to the anterior aspect of the arm, and intersecting the projected line with a vertical line in the middle of the muscle belly when viewed from the front.

(*Note* : This may be medial from the mid-line of the anterior surface of the arm)

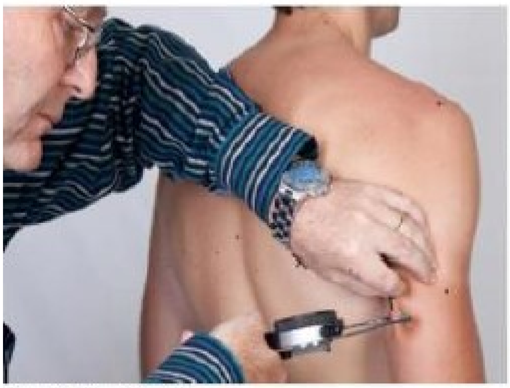


Figure 40: Triceps® skinfold

5 Triceps®

Definition: The skinfold measurement taken parallel to the long axis of the arm at the Triceps skinfold site®.

Subject position: The subject assumes a relaxed standing position with the right arm hanging by the side and the hand in the mid-prone position.

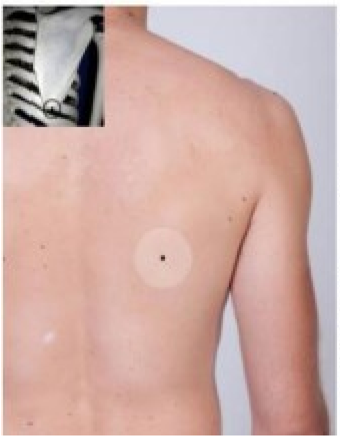
Method. Palpation of this site (where the mid-line of the posterior surface of the arm meets the projected mid acromiale-radiale perpendicular to the arm's long axis) is recommended before measurement.

7 Biceps®

Definition: The skinfold measurement taken parallel to the long axis of the arm at the Biceps skinfold site®.

Subject position: The subject assumes a relaxed standing position with the right arm hanging by the side and the hand in the mid-prone position.

Method. Palpation of this site (where a vertical line in the middle of the muscle belly when viewed from the front meets the projected mid acromiale-radiale) is recommended before measurement.



Subscapulare®

Definition: The undermost tip of the inferior angle of the scapula.

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.

Location: Palpate the inferior angle of the scapula with the left thumb. If there is difficulty locating the inferior angle of the scapula, have the subject slowly reach behind the back with the right arm. The inferior angle of the scapula should then be felt continuously as the hand is again placed by the side of the body. Mark the undermost point as a dot when located. A final check of this landmark should be made with the hand by the side in the relaxed position.

Subscapular skinfold site®

Definition: The site 2 cm along a line running laterally and obliquely downward from the Subscapulare® landmark at a 45° angle.

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.

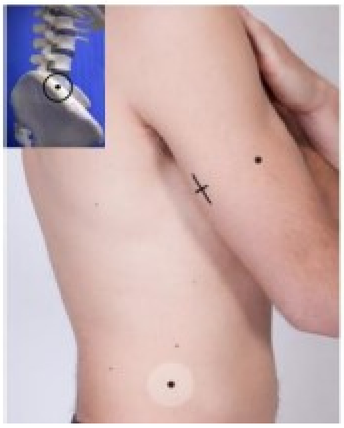
Location: Draw a line from the marked Subscapulare® laterally downward at an angle of 45°. At a point 2 cm from the Subscapulare®, draw a second line, perpendicular to the first, to indicate the alignment of the finger and thumb when picking up the skinfold.

6 Subscapular®

Definition: The skinfold measurement taken with the fold running obliquely downwards at the Subscapular skinfold site®.

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.

Method: The line of the skinfold is determined by the natural fold lines of the skin.



Iliocristale®

Definition: The most superior point on the iliac crest where a line drawn from the mid-axilla (middle of the armpit), on the longitudinal axis of the body, meets the ilium.

Subject position: The subject assumes a relaxed position with the right arm folded across the chest.

Location: Use the left hand to stabilise the body by providing resistance on the left side of the pelvis. Find the general location of the top of the iliac crest with the palms of the fingers of the right hand. When the general position has been located, find the superior aspect of the crest by horizontal palpation with the tips of the fingers. Once identified, draw a dot or short horizontal line at the level of the crest, vertically below the mid-point of the axilla.

Iliac crest skinfold site®

Definition: The site at the centre of the skinfold raised immediately above the marked Iliocristale®.

Subject position: The subject assumes a relaxed position with the right arm folded across the chest.

Location: This skinfold is raised superior to the Iliocristale. To do this, place the left thumb tip on the marked Iliocristale® site, and raise the skinfold superior to the mark, between the thumb and index finger of the left hand. Once the skinfold has been raised, mark its centre with a cross (+). The fold runs slightly downwards anteriorly as determined by the natural fold of the skin.

8 Iliac crest®

Definition: The skinfold measurement taken near horizontally at the Iliac Crest skinfold site®.

Subject position: The subject assumes a relaxed standing position. The right arm should be either abducted or placed across the trunk.

Method: The line of the skinfold generally runs slightly downward posterior-anterior, as determined by the natural fold lines of the skin.

Iliospinale®

Definition: The most inferior or undermost part of the tip of the anterior superior iliac spine.

Subject position: The subject assumes a relaxed position with the right arm folded across the chest.

Location: Palpate the superior aspect of the ilium and follow it anteriorly until the anterior superior iliac spine is reached. The landmark is marked with a dot at the undermost aspect of the iliac spine. Locating the landmark may be made easier by the subject flexing and/or laterally rotating the hip joint.

Note: On females, the landmark is usually proportionally lower on the trunk, due to the flatter and broader shape of the female pelvis.

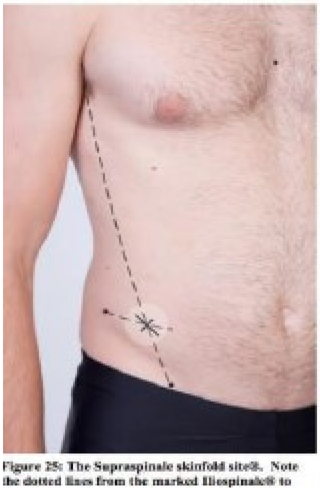


Figure 25: The Supraspinale skinfold site®. Note the dotted lines from the marked Iliospinale® to

Supraspinale skinfold site®

Definition: The point at the intersection of two lines:

(1) the line from the marked Iliospinale® to the anterior axillary border, and

(2) the horizontal line at the level of the marked Iliocristale®.

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides. The right arm may be abducted after the anterior axillary border has been identified.

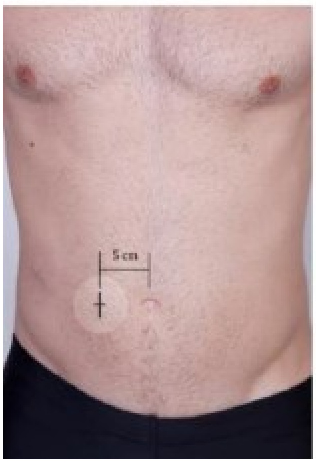
Location: Run a tape from the anterior axillary border to the marked Iliospinale®. [The subject can assist by holding the stub of the tape in position at the anterior axilla.] Draw a short line along the side of the tape roughly at the level of the Iliocristale®. Then run the tape horizontally around from the marked Iliocristale® to intersect the first line. Once the point of the intersection is located, draw another cross at the intersection to indicate the correct orientation of the skinfold, i.e. in line with the natural fold of the skin.

9 Supraspinale®

Definition: The skinfold measurement taken with the fold running obliquely and medially downward at the Supraspinale skinfold site®.

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.

Method: The fold runs medially downward and anteriorly at about a 45° angle as determined by the natural fold of the skin.



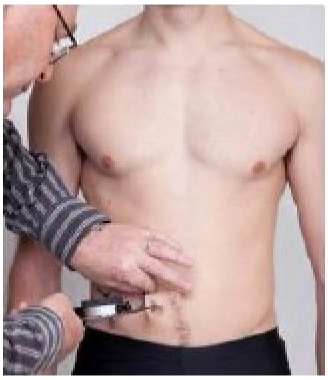
Abdominal skinfold site®

Definition: The point 5 cm horizontally to the right hand side of the omphalion (midpoint of the navel).

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.

Location: The site is identified by a horizontal measure of 5 cm, to the subject's right, from the omphalion. The skinfold taken at this site is a vertical fold.

[*Note*: The distance of 5 cm assumes an adult height. Where height differs markedly from this, e.g. in young children, the distance should be scaled for height. For example, if the stature is 120 cm, the distance will be 5 x 120/170 = 3.5 cm.]



10 Abdominal®

Definition: The skinfold measurement taken vertically at the Abdominal skinfold site®.

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.

Method: It is particularly important at this site that the measurer is sure the initial grasp is firm and broad since often the underlying musculature is poorly developed. This may result in an underestimation of the thickness of the subcutaneous layer of tissue. (*Note*: Do not place the fingers or caliper inside the navel.)

Patellare®

Definition: The midpoint of the posterior superior border of the patella.

Subject Position: The subject sits on the edge of the box with the right leg straight out and heel on the floor.

Location: The measurer palpates the patella from the lateral and medial sides, working up to the superior border. The posterior surface is palpated through the patellar tendon. With the measurer's thumbnail at the posterior superior border, the subject flexes the knee to 90° and the site is marked.

Note: It is very difficult to palpate the posterior superior border with the knee flexed, due to the tension in the patellar tendon, and although the change in orientation of the patella during knee flexion alters the precise location of the landmark, the above remains the most reliable means of marking it in practice.

Front thigh skinfold site®

Definition: The mid-point of a line between the Patellare® and the Inguinal Point®.

Subject position: The subject assumes a seated position on the edge of the box with the torso erect and the arms hanging by the sides. The knee of the right leg should be bent at a right angle.

Location: The measurer stands facing the right side of the seated subject on the lateral side of the thigh. If there is difficulty locating the Inguinal Fold® the subject should flex the hip to make a fold. Place one end of the measuring device on the Patellare and the other end on the Inguinal Point. Measure the distance between the two landmarks and place a small horizontal mark at the level of the mid-point. Now draw a perpendicular line to intersect the horizontal line. This perpendicular line is located in the midline of the thigh. If a tape is used, be sure to avoid following the curvature of the surface of the skin.

11 Front thigh®

Definition: The skinfold measurement taken parallel to the long axis of the thigh at the Front Thigh skinfold site®.

Subject position: The subject assumes a seated position at the front edge of the box with the torso erect, the arms supporting the hamstrings and the leg extended and heel on floor.

Method: Because of difficulties with this skin-fold, two methods are recommended. These are illustrated in Figures 46A and 46B. Be sure to record on the proforma the method used as A or B. In both methods the leg is extended, and the subject supports the hamstrings by lifting the underside of the thigh.

Method A The measurer stands facing the right side of the subject on the lateral side of the thigh. The skinfold is raised at the marked site, and the measurement taken.

Medial calf skinfold site®

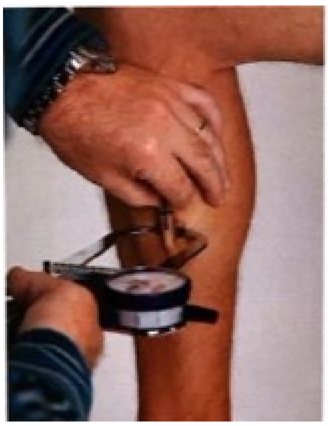
Definition: The point on the most medial aspect of the calf at the level of the maximal girth.

Subject position: The subject assumes a relaxed standing position on the box with the arms hanging by the sides. The subject's feet should be separated and the weight evenly distributed.

Location: The level of the maximum girth is determined by trial and error. It is found by using the middle fingers to manipulate the position of the tape in a series of up or down measurements. Once the maximal level is located, it is marked on the medial aspect of the calf with a short horizontal line.

A vertical line is then marked on the medial aspect of the calf to indicate the skinfold site. [This mark may be more easily made with the subject's left foot on the floor.]

Note: Due to the difficulty of photographing the skinfold site with the subject standing on the box, the illustration depicts the site after it has been located, with one foot on the floor



12 Medial calf®

Definition: The skinfold measurement taken vertically at the Medial Calf skinfold site®.

Subject position: The subject assumes a relaxed standing position with the right foot placed on the box. The right knee is bent at about 90°.

Method: The subject's right foot is placed on a box with the calf relaxed. The fold is parallel to the long axis of the leg.

Note: Remember the landmark is located and marked with the body weight equally distributed on both legs. The skinfold measurement is made with the R knee flexed to 90° in order to reduce muscle tension, making the fold easier to measure.

Appendix G: Programme for 3RM test.

SET	WEIGHT	REPS	REST
Warm Up	40%	5	3-4 mins
1	50%	5	3-4mins
2 (Max)	Max/3	3	0

Appendix H: Test design for Yo-YoIRT1