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STRENGTH AND SPEED PROFILE OF A FINNISH UNDER-19 FUTSAL NATIONAL TEAM PLAYER

Santa Sport

Demidoff Marko

Master´s Thesis

Expertise in Exercise and Sports Coaching
Master of Health Care
2024

LAPIN AMK
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Opinnäytetyön tiivistelmä

Liikunnan ja urheiluvalmennuksen asiantuntija
Fysioterapeutti YAMK

Tekijä Marko Demidoff **Vuosi** 2024
Ohjaaja(t) Sami Kalaja ja Eija Jumisko
Toimeksiantaja Santa Sport

Työn nimi Suomalaisen alle 19-vuotiaan futsalmaajoukkuepelaajan voima- ja nopeusprofiili
Sivumäärä 38

Tämä opinnäytetyö tarkastelee suomalaisen alle 19-vuotiaan futsal-maajoukkuepelaajan nopeus- ja voimaprofiilia. Tutkimuksen tarkoituksena on määrittää nuoren pelaajan suorituskyky voiman, juoksunopeuden ja nopean voimantuoton osalta. Tutkielman tavoitteena oli luoda viitearvot fyysiselle suorituskyvylle, joita voidaan hyödyntää fyysisen harjoittelun suunnittelussa. Tavoitteena oli myös edistää harjoittelukulttuuria, jakaa tutkittua tietoa maailmanlaajuisen futsalyhteisön kanssa ja innostaa sen jäseniä tuottamaan vastaavia tutkimuksia tulevaisuudessa.

Tutkimuskysymyksiin kuului, millainen on nuoren pelaajan antropometrinen profiili ja kuinka paljon nuori maajoukkuepelaaja kyykkää, nostaa maasta maastavedossa ja trap bar -maastavedossa, ja kuinka suuren kuorman pelaaja voi nostaa tangossa tehtävässä lantionnostossa. Nopeuden ja nopean voimantuoton osalta tutkimuskysymykset keskittyvät siihen, kuinka korkealle nuori maajoukkuepelaaja hyppää vertikaalisesti, kuinka pitkälle hän hyppää vauhditonta pituutta tai yhdellä jalalla tehtävässä lateraalihypyssä, ja kuinka nopeasti hän juoksee 20 metrin matkan. Tutkimusdata kerättiin Suomen U19-futsalmaajoukkueen leireillä vuosina 2021-2023. Teoreettinen viitekehys korosti futsalin analysointia, erityisesti pelin fyysisiä pelaajakohtaisia vaatimuksia. Testien valinta perusteltiin futsalin olennaisten liikesuuntien ja alaraajojen lihaksistoon kuuluvien lihasryhmien näkökulmasta. Tämä opinnäytetyö käytti kvantitatiivista tutkimusmenetelmää, esittäen testitulokset numeerisesti keskiarvoina, vaihteluväleinä, mediaaneina, moodina ja keskihajontana. Lisäksi tuloksia verrattiin olemassa oleviin eliittitason aikuispelaajiin, mikäli sellaisia tutkimustuloksia oli saatavilla.

Suomen alle 19-vuotias futsal-maajoukkuepelaaja on suhteellisen vahva ja nopea verrattuna aikuistason eliittipelaajiin. Tämän tutkielman esittämiä tutkimustuloksia voidaan soveltaa futsal-pelaajien fyysiseen harjoitteluun, ohjaamaan harjoitteiden valintoja, testaukseen ja tavoitteiden asetteluun.

Avainsanat futsal, nopeus, voima, maksimivoima, nopeusvoima, testaus

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Abstract of thesis

Expertise in Exercise and Sports Coaching
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Author	Marko Demidoff	**Year**	2024
Supervisor(s)	Sami Kalaja and Eija Jumisko		
Commissioned by	Santa Sport		
Title	Strength and Speed Profile of a Finnish Under-19 Futsal National Team Player		
Number of pages	38		

This Master´s thesis examines the speed and strength profile of a Finnish national under-19 futsal team player. The purpose of the study is to determine the performance level of a young player in terms of strength, running speed, and rapid force production. The goal of the thesis was to establish reference values for physical performance that can be utilized in designing physical training. The objective was also to enhance training culture, share researched information with the global futsal community, and inspire members of the futsal community to produce similar studies in the future.

Research questions included what is the anthropometric profile of a young player and how much a young national team player squats, lifts a deadlift and trap bar deadlift from the ground, and what load the player can lift in the barbell hip thrust. Regarding speed and rapid force production, the research questions focus on how high the young national team player jumps in a vertical jump, how far they jump in a standing broad horizontal jump or a single-leg lateral jump, and how quickly they cover a 20-meter distance in a photocell sprint. The research data was collected during the Finnish U19 futsal national team camps from 2021 to 2023. The theoretical framework emphasized futsal game analysis, particularly the physical player-specific requirements of the sport. The selection of tests were justified from the perspective of futsal's essential movement directions and the muscle groups used in the lower extremities. This Master´s thesis employed a quantitative research method, presenting test results numerically as averages, ranges, medians, modes and standard deviations. Additionally, the results are compared to existing elite adult futsal players, if such research findings were available.

The Finnish under-19 futsal national team player is relatively strong and fast when comparing their performance to elite adult players. The research findings presented in this thesis can be applied in the physical training of futsal players, guiding exercise selection, testing and goal-setting.

Keywords futsal, speed, strength, maximum strength, power, testing

CONTENTS

FOREWORD

The Master´s Thesis process has been long and rewarding. I want to thank, above all, the coaching and support team of the Finnish national futsal team under 19, as well as the players from two different age groups for their collaboration and efforts. I especially want to thank the team's head coach Kerkko Huhtanen for trusting in my abilities, enabling the tests for the national team events and contributing to the development of futsal in Finland. Recognition also goes to the former head coach of the futsal national team, Mićo Martić, whose encouraging and inspiring discussions have been beneficial to the process. I´d like to thank my colleague Tuomas Linjamäki for providing help conducting the tests. Additionally, I want to express my gratitude to Heikki Hannola of Santa Sport and my supervisors Sami Kalaja and Eija Jumisko. Lastly, I want to thank the Finnish futsal community for their interest in my work. Your curiosity about my topic has motivated me in my work.

1. INTRODUCTION

Futsal has been increasing its popularity worldwide for years. Additionally, there is a growing data of research related to futsal, although there are still many knowledge gaps to fulfill. Research findings include data on running distances during the game, workload, the number of sprints and heart rate zones are well covered (Naser 2017). The evolution of the game has featured continually accelerating gameplay, therefore demanding higher physical performance levels from players to succeed in international matches. Futsal places a strong emphasis on rapid perception and quick decision-making, which also requires players to have fast visuomotor abilities. How should the physical training for futsal be put in practice? What qualities does the sport itself develop and which aspects of physical performance should be trained alongside the sport-specific training? A comprehensive speed-strength profile has been lacking for both international-level men, women and under-19 men, which could provide performance target areas and guidance for futsal physical conditioning. Spyrou (2020) calls for the need to assess players' strength, speed and agility performance levels.

Perhaps the well-implemented and year-round strength training has been absent from the sport's culture for a long time. Futsal is no exception from the well known ballgame dilemma, where the physical training is more endurance-type circuit training which primarily develops endurance strength. However, the relative and absolute maximum strength provide the basis for rapid force production, a crucial attribute in all ball sports. This thesis presents guidelines for the speed and strength profile in futsal based on test results from young national team players, game analysis and the principles of strength and speed training. The data for this thesis was collected retrospectively from speed and strength tests of national team candidate players born in the years of 2002 and 2004, conducted under supervision during national team events from 2020 to 2023.

In futsal coaching education, the latest and updated knowledge of strength and speed training is needed because sport-specific training primarily develops endurance qualities as mentioned. This knowledge is crucial for comprehensive athlete development. Additionally, understanding physical testing and concrete tests is required for evaluating the effectiveness of training. Physical testing should be based on game analysis, so from the perspective of coaching planning and implementation, it is crucial to understand the types of movements, joint angles, force production times, energy production mechanisms, muscle work modes in the sport, and which muscle groups are essential for game performance (Rytkönen 2018). Athletes' chances of success and achieving their goals improve when coaching effectively implements the testing process (Lambert 2006). This thesis and the information it contains have been created to serve the domestic and global futsal community.

2. THE PURPOSE, THE GOAL AND THE RESEARCH QUESTIONS

The purpose is to establish target values for the speed and strength profile of a U19 national team-level futsal player based on the average test results, statistical analysis and the previous international research findings. These target values facilitate training program design and add a motivating goal element to the training. The more information we can provide about the physical requirements of futsal players, the more effectively we can potentially coach physical performance, as training and time resources can be precisely targeted to the most important areas.

It is well known that long-term exposure to futsal leads to enhanced aerobic fitness and cardiac autonomic regulation, but sadly it impairs muscular strength and speed performance (Mendes 2022). Then the question is: do we want to have fast and strong players or just keep on going like we´ve always have? Therefore, this Master´s thesis´s goal is to share knowledge that could possibly have an effect on the physical performance coaching in the sport of futsal.

The research questions included the anthropometric profile of a young player and how much a young national team player squats, lifts a deadlift and trap bar deadlift from the ground, and what load the player can lift in the barbell hip thrust. Regarding speed and rapid force production, the research questions focus on how high the young national team player jumps in a vertical jump, how far they jump in a standing broad horizontal jump or a single-leg lateral jump, and how quickly they cover a 20-meter distance in a photocell sprint. This Thesis was made with collaboration with Santa Sport, the center of sports and well-being in Rovaniemi, Finland.

3. FUTSAL GAME ANALYSIS AND PHYSICAL PERFORMANCE REQUIREMENTS

Futsal is a high-intensity ball game played on a field measuring 20 x 40 meters. There are two halves, each lasting 20 minutes, with a maximum 15-minute break between them. The game clock stops during game interruptions (ball out of bounds, fouls, corner kicks), so the 20 minutes constitute so-called active playing time, making the total game time approximately 75-90 minutes (Spyrou 2020.) High intensity, in elite-level futsal, means that the heart rate is above 85% of the maximum for over 80% of the game time (Spyrou, 2020). A characteristic feature of futsal includes repeated high-speed running performances and directional changes. Additionally, approximately 25% of a field player's movement in futsal occurs backward and sideways (Dogramaci 2015.)

According to Ayarran (2018), a futsal player needs not only high-level aerobic endurance but also significant maximum and speed strength to perform efficiently in sport-specific actions, such as sprint accelerations, directional changes, sprint decelerations, tackles and jumps. Sekulic (2019) has defined agility requirements for different playing positions. A pivot player should be able to hold the ball and make good passes. A winger should be capable of quick sprints and passes. A pivot player should be able to attack and score goals. Additionally, a futsal player should possess exceptional agility, meaning an excellent perception-reaction-action relationship.

Furthermore, the player-specific roles have been defined from a game perspective. Goalkeepers should act as the last line of defense, coordinating the team's defensive play by communicating and directing other players. The back player's primary task is to organize the game, provide defensive support in synchrony with other players and disrupt the opponent's attacking play through their actions. Wingers are responsible for balancing defense and offense concerning events along the field's sidelines. The pivot player should be the

most advanced field player on the team. The pivot player needs the ability to play with their back to the opponent's goal, pass the ball to the wingers, quickly change direction with the ball, and score goals (Borges 2022.)

In futsal, a typical sprint covers a distance of 8-20 meters and lasts for 2-4 seconds (Spyrou 2020). Additionally, a futsal player sprints approximately every 7-9 seconds (Borges 2022). At the elite level, there are about 26 sprints in a single game (Spyrou 2020). Futsal is a high-intensity ball game that requires not only good endurance but also the ability for repeated high-speed running performances and directional changes that utilize maximum and speed strength qualities (Naser 2017). From the perspective of coaching planning and implementation, it is crucial to understand, based on game analysis, the types of movements, joint angles, force production times, energy production mechanisms, muscle work modes in the sport and which muscle groups are essential for the game performance (Rytkönen 2018).

Unfortunately, there is only a few analyses on psychological aspects among futsal players. Generally, in sports, the valued abilities among top-performing athletes are elevated decision-making abilities, creative actions, strong concentration and reaction times. However, some insights of the psychological factors have been studied, such as decision-making processes, electro-cortical activity, reaction time, teaching–learning-training approaches and the crucial elements of self-confidence and stress control. (Mendes 2022). Especially stress control can be detrimental to physical and mental health as well as to sport performance. (Dos Santos 2020). The results shown in Mendes (2022) highlight the importance of psychological factors in the success of futsal careers. Specifically, goalkeepers stood out with the most advantageous psychological profile, while pivots and wing-pivots displayed lower self-confidence and universal players faced difficulties in stress control compared to players in other positions. Furthermore, the emphasis on decision-making during training was associated with improved intelligence and creative performance among players. These combined findings underscore the diverse impact of psychological factors in the domain of futsal, offering a basis

for continued research and practical implementations aimed at enhancing players' mental attributes for success in the sport. (Mendes 2022.)

3.1 Futsal players anthropometrics

Anthropometry refers to the measurement of players' proportions and body composition. It is derived from the Greek words "anthropos" meaning human and "metron" meaning to measure. While excess mass can impair physical performance, a relatively high proportion of muscle mass improves physical performance. Greater muscle mass enables higher production of strength and speed. (Vila Suárez 2008.)

There are research on the anthropometry of futsal players in 10 studies, measuring body composition, weight, and height. In these datasets, futsal players had an average weight of about 70 kilograms, an average height of approximately 176 centimeters, and a body fat percentage of around 15%. Notably, there was not a significant difference in anthropometry between professional and semi-professional players in these research findings. Regarding body composition, research indicates that pivot players have the highest body fat percentages, followed by goalkeepers and the base players. Wingers seem to have the least amount of fat mass. (Spyrou 2020.)

3.2 The most important lower limb muscle groups for futsal

Football and futsal share similarities in terms of the muscle groups used in movements. In both sports, players perform jumps, sprints, changes of direction and sport-specific actions like passing and shooting, which require quick and powerful lower limb movements. (Rodriguez-Rosell 2017.) Among the lower limb muscles, the quadriceps and hamstrings play a crucial role anatomically and biomechanically. They are largely involved in jumps, sprints, changes of direction and accelerations. (Comfort 2014.) Regarding the rate of force development in vertical jumps, the muscles emphasized include the ankle

plantar flexors (calf muscles) and the knee extensor muscles (quadriceps). (Chang 2015.)

The hip adductor muscles are essential for hip and pelvic stability. (Hrysomallis 2009). The concentric and eccentric muscle strength of the hip muscles in the hip area becomes particularly important in futsal during changes of direction and acceleration and deceleration in running. (Karatrantou 2019). In rapid changes of direction, the eccentric (braking) muscle work of the hip adductors, including adductor longus, semitendinosus, biceps femoris, and gastrocnemius muscles are emphasized.(Falch 2020). The role of the calf complex (triceps surae) is vital in futsal movements. Its maximal force production during standing ankle plantar flexion is related to the height of squat jumps, countermovement jumps and drop jumps (Möck 2023), as well as maximum acceleration in the 0-30 m sprint (Möck 2018).

3.3 Maximum strength

The generation of maximal strength is crucial in sports, including team sports (Warneke 2023). Several studies show that athletes with higher levels of maximal and speed strength are faster, have better agility and can jump higher (Spyrou 2020). Maximal strength refers to the highest individual level of force that the neuromuscular system can produce from the body in a specific movement. Maximal strength is an important attribute for athletes because it determines the potential for force production. In practice, the greater the reserve of maximal strength, the more potential for force production. (Rytkönen 2018.) Athletes with lower maximal strength levels should first develop maximal strength before moving on to power training, as training is more effective with a larger maximal strength reserve (Suchomel 2018).

There can be a significant maximum strength without substantial muscle mass. In some sports, there is a preference for not developing large muscle mass even in the primary muscles responsible for the movement, despite the need for high maximum force production. In such sports like futsal, an adequate

maximum strength reserve as a foundation to quality speed-strength training can be developed through progressive low-volume maximum strength training. This involves performing sets of 1-5 repetitions while keeping the total volume below 70 repetitions per muscle group per week. This type of training helps enhance the neuromuscular capacity of muscles, muscle quality for maximum force production and the ability of supporting connective tissues to transmit force without significant muscle growth. However, it is important to note that this type of strength training does not eliminate muscle mass growth entirely. (Rytkönen 2018, 58.)

In addition, it is essential to understand the *principle of diminishing returns* when working with a novice in strength training. This principle means that beginners experience significant improvements with even a small amount of effective training. On the other hand, advanced and experienced athletes find it more challenging to make progress, even with high-quality and high-volume training (Rytkönen 2018, 29). In the world of strength training, beginners are considered to be individuals who have trained for less than a year, the intermediates have trained for 1-4 years and experienced athletes have engaged in progressive strength training for over 4 years. (Rytkönen 2018.)

According to Spyrou (2020), there is a need for more research on assessing the strength capacity of futsal players. The majority of the current studies used isokinetic dynamometry as the main research tool. However, isokinetic testing is very time-consuming and requires expensive equipment. Therefore, other methods should be considered and used for measuring strength, such as 1RM squats, deadlifts and hip thrusts.

3.4 Testing the maximum strength

The 1RM test or one-repetition maximum test is often considered the *"gold standard"* for assessing an individual's strength capacity outside of a laboratory environment (Levinger 2009). It is simply defined as the heaviest weight an

individual can lift for a single repetition with certain technique. Strength and conditioning coaches commonly use the 1RM test to evaluate strength capacity and the effectiveness of training programs (Braith 1993). Due to its simplicity, time efficiency, affordability and reliability, the 1RM test is a highly popular testing protocol.

Various 1RM tests are safe and reliable strength measures for young children aged 6-12 (Faigenbaum 2003), adolescent athletes aged 15-17 (Faigenbaum 2012), as well as healthy adults, both trained and untrained, aged 18-36 (Ribeiro 2013; Urquhart 2015). In the Finnish under-19 national team events, maximum strength has been tested for the back squat, deadlift, trap bar deadlift and hip thrust.

The back squat is a test of the vertical movement pattern, primarily assessing maximal strength in the quadriceps and gluteal muscles. The squat is considered one of the most critical movement patterns for improving physical performance, reducing the risk of injury and supporting lifelong physical activity. (Myer 2014.) According to Keiner (2013), individuals aged 16-19 who have been strength training for a longer period should perform a parallel squat with a load of at least 2.0 times their body weight. Among Finns, the best relative result for a deep back squat is achieved by a player weighing 76 kilograms, lifting 140 kilograms, which is 1.842 times body weight. The hip thrust´s best relative strength result was 77 kilogram player liftin 230 kilograms, which means 2,98 times body weight.

The deadlift involves a vertical-horizontal movement pattern that combines maximal force production from the quadriceps and gluteal muscles, as well as the erector spinae (long back extensor) and biceps femoris (two-headed thigh muscle) (Martín-Fuentes 2020). Furthermore, the deadlift activates more biceps femoris than hip thrust and trap bar deadlift (Andersen 2017).

The hip thrust is a horizontal movement used to measure maximal hip extension strength. It develops horizontal force production, and a high level of strength in this context is correlated with sprinting performance according to the theory of

the force-velocity vector. Hip thrust quickly gained popularity in the fields of biomechanics and strength and conditioning after Contreras' (2011) publication of the *Barbell Hip Thrust* study, which demonstrated superior gluteal muscle activation compared to variations of deadlifts and back squats. (Brazil 2021.) Trap Bar Deadlift is a vertical movement pattern, emphasizing maximum strength of the quadriceps and glutes with a smaller knee angle compared to deep squats. The knee angle is in this case similar to half-squat, which maximum performance is known to correlate with maximum running speed among elite-level football players. (Wisloff 2004.)

3.5 Speed and power testing

The evaluation of speed has become a fundamental aspect of performance assessments (Altmann 2019). Speed testing is often based on running because it is practical to implement at the functional level. Concerning testing, there are options for linear speed and change of direction speed tests. (Vesterinen 2022.) In linear sprinting, traditional futsal testing has included 5, 10, and 20-meter sprint distances measured with photocells (Loturco 2018).

While it is evident that short-distance speed is essential for most team sports athletes, possessing a high maximal running velocity is equally crucial. Team sport athletes typically reach their maximal velocity during longer sprints after 30-40 meters. This is significant for athletes as maximal sprints in team sports often start from a moving position. Although sprints of such distances occur less frequently in match-play, athletes may still have the opportunity to achieve their maximal velocity if they initiate the sprint while already in motion. This implies that, alongside the vital need for acceleration development, athletes should also focus on enhancing their speed in longer-distance sprints, such as those covering 30 meters or more. (Rumpf 2015). In the case of world-class sprinters, maximum velocity is typically achieved between 50-80 meters in a 100-meter race (Healy 2022), so to reach maximum speed, an adequate acceleration distance is needed.

Power refers to the ability to produce as much force as possible in a short amount of time Typical tests for power include maximal single jumps, such as vertical jump, lateral side jump or standing broad jump as well as various multiple jumps, such as the standing five-jump, 3-hop test or 3-bound test. (Rytkönen 2018.) The standing long jump is a typical test for assessing rapid force production in the lower extremities, which has been found to be effective and easy to use (Wei 2022).

Explosive force production in the legs is an essential characteristic for jumping in futsal players. Explosive force production can be indirectly assessed by measuring the maximum height of a vertical squat jump. While there are fewer jumps in futsal compared to soccer as the ball is moved more along the ground in futsal, jumping ability remains a crucial attribute for success (Naser 2017.)

Loturco (2015) investigated how squat jump, loaded and unloaded vertical jump, as well as horizontal jump correlated with running speed in team sport athletes and non-elite sprinters. Based on the comparison, it can be noted that the height of the unloaded vertical jump and the length of the horizontal jump show the strongest correlation with running speed. Loaded vertical jump and vertical countermovement jump also shows a connection, but not as strongly as the unloaded jump. In Lin (2023) meta-analysis, the relationship between horizontal jumps and sprint acceleration and maximal speed was studied. An athlete who jumps further horizontally is also faster in running performances. The strongest connections are observed in jump performances that involve consecutive horizontal jumps.

It is noteworthy that the standing long jump correlates better with maximal running speed than with the acceleration phase. Better correlations with the sprint acceleration phase are found for three consecutive standing long jumps (3-hop test) than for a single jump. Better correlations with running speed are also seen in the 5-step bound test than in a single standing long jump. (Lin 2023.) In the events of the Finnish national under-19 team, speed and power have been tested by our team using the 20-meter sprint, standing broad jump, vertical countermovement jump and one-legged standing lateral broad jump.

The countermovement jump is a simple, valid, reliable and practical vertical power test for lower limbs. In a countermovement jump, the individual initiates the jump from a standing position by first moving downward through flexion at the knees and hips. Following this initial descent, there is an immediate and forceful extension of the knees and hips to propel the body vertically off the ground. This type of jump exemplifies the utilization of the 'stretch-shortening cycle.' Numerous human activities, including running, jumping, and throwing incorporate muscle actions where the intended motion is preceded by a movement in the opposite direction. (Linthorne 2001.)

The 1-leg lateral broad jump measures lateral power and technical jumping ability (Taboga 2013). It was formerly predicted that lateral jump power would correlate highly with change of direction ability. Actually Meylan (2009) found that lateral jumps predicting sprints and change of direction ability are quite limited. However, if one jump assessment were selected to predict sprint and COD performance in a test battery, the one-leg horizontal countermovement jump would seem the logical choice. In conclusion the physical performance coach needs to select tests that have the greatest specificity to the activity of interest or run a full battery of jump tests. (Meylan 2009). Therefore we need to choose wisely which tests we conduct.

4. RESEARCH METHODS

Good scientific practice is based on many procedures such as honesty, integrity and accountability. It applies scientifically rigorous and ethically sustainable methods for data acquisition, research and evaluation, adhering to the criteria of scientific inquiry. Furthermore, it acknowledges the work and achievements of other researchers, respecting their contributions and giving them due recognition (Tuomi 2013). Good scientific practice was respected in this process for example by using reliable methods and equipment, and making sure that the test results were recorded honestly. This thesis´s research approach was quantitative research. The thesis consists of test results of various physical performance tests which are more closely described in the following chapters. Quantitative research is an investigative method which gathers numerical data and analyzes it statistically. (Creswell 2014). The participants were informed about the tests verbally and they were informed that the test results will be used in a master's thesis. From an ethical perspective, it is not possible to directly identify individuals based on the players' test results in the thesis, ensuring data privacy.

4.1 Tests

In terms of strength tests, 1RM squat, deadlift, trap bar deadlift, and hip thrust were conducted and speed and power tests, 20-meter sprint, standing broad jump, vertical countermovement jump, and 1-leg lateral broad jump were conducted. All the tests were conducted in *Eerikkilä Sports Resort in Tammela, Finland*. All tests were conducted by physiotherapist-osteopath and performance coach *Marko Demidoff* and physiotherapist *Tuomas Linjamäki.* Equipment that was used was Chronojump jumping platform (countermovement jump), Chronojump photocells (20 m sprint), tape measure was used for standing broad jump, 1-leg lateral broad jump and players height measurement.

In Chronojump jumping platform the margin of error in measurement is notably minimal, only 1.3 cm, when compared to the smallest meaningful change.

Consequently, Chronojump can be considered a highly responsive tool for identifying fluctuations in jump height performance amid the potential noise surrounding the measurement. (Pueo 2020.) Players' weights were tested with a digital scale, which provides sufficiently accurate and consistent results ($p<0.05$) (Yorkin 2013). The strength tests were done in Eerikkilä´s Functional Training environment with barbells and additional weights. All the tape measurements (player´s height and broad jumps) may have errors that can vary depending on the precision in millimeters or centimeters. However, it is important to note that human error, such as the misplacement of the tape measure or reading inaccuracy, can also influence measurement results.

The tests have been integrated into the Finnish Under-19 National team camps. The testing dates when the data was collected were 2nd August 2020, 8th September 2020, 28th December 2020, 27th August 2021, 14th January 2022, 4th July 2022, 25th August 2022, 2nd January 2023, 28th April 2023 and 3th August 2023. The testing related principle has been that the camp starts with the physical tests. Timewise the tests were conducted between 10:00 -13:00.

The test results are presented as averages along with the range of the highest and lowest results. There are also median, mode and standard deviation values presented in each test. Additionally, the position specificity between field players and goalkeepers has been taken into account. The test results have been compared to previous studies conducted on futsal players, whenever such studies and test result details were available.

The 1RM squat test was conducted with an initial weight of 60 kilograms. The load was increased by 10 kilograms at a time. Prior to this, the players were allowed to warm up on their own. The test criteria for the back squat are based on the powerlifting competition rules, requiring a descent from the standing position to a depth where the upper surface of the thighs is lower than the upper part of the knees at the hip joint (Finnish Powerlifting Federation 2023). This ensures a consistent movement pattern and repeatability in testing. In the test we used other players and national team staff to spot during the lifts.

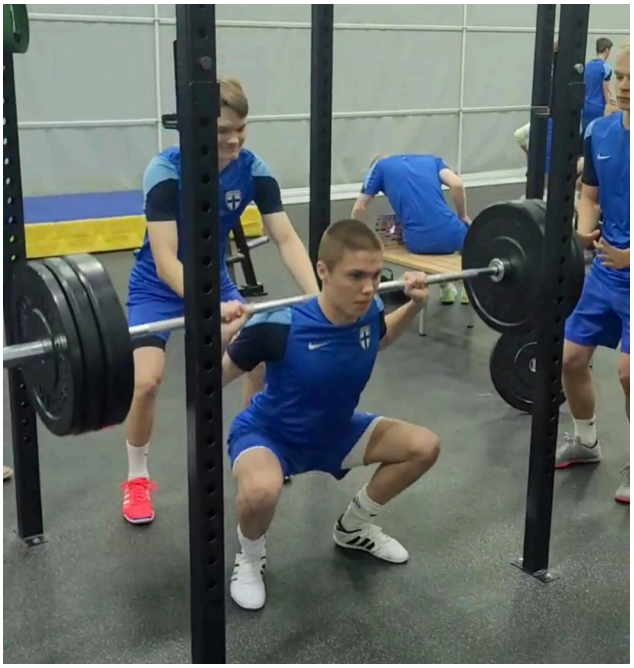

Figure 1. 1RM squat test downward position.

The maximum one-repetition deadlift test began with an initial weight of 40 kilograms. Subsequently, the weight was raised by 10 kilograms. Prior to the test, the players were given the opportunity to conduct their own warm-up routines. The test criteria for the deadlift are based on the powerlifting competition rules. In the beginning the lifter bends at the hips and knees, lowering their body to grip the bar. The back should be straight, and the chest up. Then the person starts the lift where the person is required to stand fully erect with shoulders back at the top of the lift. (Finnish Powerlifting Federation 2023.)

The Trap Bar 1RM test began with an initial weight of 66 kilograms, and the load was initially increased by 20 kilograms up to 126 kilograms. After reaching 126 kilograms, the weight was then increased by 10-kilogram. In the starting position, the player grips the handles of the bar, slightly extends their back, and looks slightly upward and forward. The lift is executed by extending the knees and hips, and the criterion for the finishing position is that the knees are fully extended, and the back remains straight.

Figure 2. 1RM trap bar test upward position.

The hip thrust test begins with an initial weight of 100 kilograms. The load is increased 10 kilograms in every stage. The purpose is to lift the weight from the ground to the horizontal level where the knee and hips are aligned. The bar is placed on the upper section of the femur.

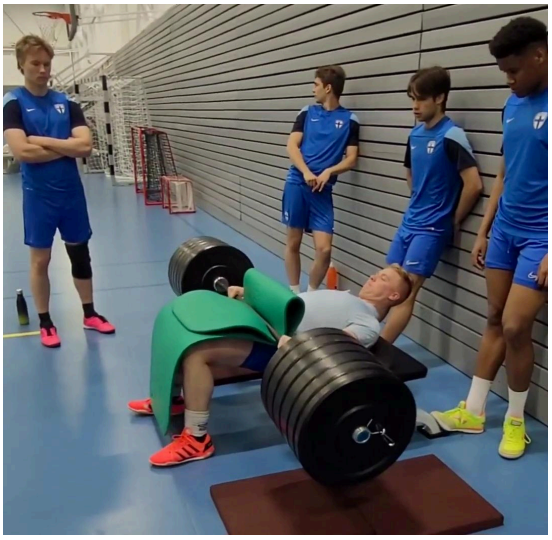

Figure 3. 1RM hip thrust test upward position.

Since all the maximum strength tests were conducted by the same person there can be a possibility of an error when assessing the correct lifting techniques.

Countermovement jump test was conducted with Chronojump Boscosystem jump platform which is connected to a laptop. Chronojump platform is a reliable and valid instrument for measuring vertical jump height (Pueo 2020). Players had 5 jumps and best results were recorded. In the test the players were free to use their hands during the takeoff and jump.

The 20-meter sprint test was conducted with photocells from Boscosystem. Photocells were connected to a laptop. The player starts from 70 cm from the first photocell laser. The clock starts when the player passes the first photocell and the clock stops when the player reaches the second photocell. Photocells are accurate and reliable divides to measure time in sprints. Players had two attempts, and if they improved their time on the second, the player would always get another attempt if their result improved.

Standing broad jump was conducted using tape measure. The players position themselves behind a marked line on the ground, feet slightly apart. Employing a two-foot take-off and landing, they utilize a swinging motion of the arms and bending of the knees to generate forward momentum. The objective is to achieve the farthest jump possible, landing on both feet without falling backwards. There was no limitation of jumps per player. The result of the jump was measured from the leg which landed a shorter distance.

The 1-leg lateral broad jump was conducted in a similar way to standing broad jump using tape measure as a measurement tool. The player positioned themselves sideways behind the marked line on the ground standing with one foot. Before jumping the players bend their knees to create lateral momentum. The objective is to reach as far as possible and land on one foot. The players got 3 jumps each leg and the best results were recorded.

4.2 Statistical analysis

Statistical analysis consists of information about the T-test, U-test, average, range, mode, median and standard deviation of the data and some examples.

The statistical analysis tool used is the T-test, which aims to determine whether there is a statistically significant difference between the means of the research results for two different groups. In many studies, the reference value is set at 0.05 or 5%, and results below this threshold are interpreted as a significant difference. (Kim 2015.) In the T-test it is needed to have an equal amount of data results from two groups (Kim 2015). Therefore the T-test was conducted only with the results of 1-leg lateral broad jump between right and left side. The 1-leg lateral broad jump shows no significant difference between two groups - right and left side where the result is 0.094 or 9.4%.

In addition, in the statistical analysis, one could consider the Mann-Whitney U-test, which aims to compare the distribution of the investigated characteristic in two groups. It is suitable for a test when the data is not normally distributed. The test is accurate when measuring a quantitative trait. This test is used especially when determining whether the means of two groups are statistically significantly different (Hart 2001.) The U-test could not be implemented in the comparison between Finnish and other nationalities' test results because individual test results were not available. Instead, for example, the significance of the averages of the results for outfield players and goalkeepers was compared in the 20 m sprint test. The z-score is 0.08907. The p-value is .92828. The result is not significant at $p < .05$.

Mode and median values were also determined in addition to the average and range values. Mode is a statistical concept that refers to the value in a dataset that occurs most frequently. In other words, the mode is the value that repeats the most in the dataset. Mode is particularly useful in describing the location of the peak or high point of a distribution. Median is another measure of central tendency that arranges the values of a dataset in order and selects the middle value. If the dataset contains an even number of values, the median is the average of these two middle values. (Zulfiqar 2016.)

Standard deviation, commonly represented by the symbol σ (sigma) in statistics, refers to how much a distribution stretches or compresses among the values within a dataset. A smaller standard deviation implies that data points

are more closely clustered around the mean or expected value, μ - micron. Conversely, a larger standard deviation suggests a broader range of values. Standard deviation is frequently employed in assessing statistical outcomes, such as the margin of error. (Zulfiqar 2016.)

5. RESEARCH RESULTS

The number of tested players among Finnish under-19 players varies depending on the specific test because there is a varying number of players present at national team events. Additionally, not all players who have attended national team camps may have participated in physical tests for every test, as the implementation of tests has varied between national team events. The test results were compared to previous test results from men's elite level futsal if such test results were available.

5.1 Under-19 players antropometrics

For Finnish under-19 national futsal team players (N=65) in the anthropometric averages are approximately 76.61 kilograms for weight and 178.41 centimeters for height. More detailed information on the table below.

Table 1. Height and weight of the players

Test	N =	Subgroup	Average value	Range	Median	Mode	Standard deviation
Height	65	All together	178,41 cm	170 - 193 cm	178 cm	176 cm	18,39
Weight	65	All together	76,61 kg	60 - 99 kg	75 kg	75 kg	7,68

5.2 Test results of power and speed

For the countermovement jump, the performance level of Spanish professional futsal players is 35.9 ± 5.29 cm (N=12) (Cuadrado Peñafiel 2014). In the dataset of Loturco (2018), consisting of 63 Brazilian elite-level players, the result was 38.50 ± 4.88 cm. The average performance level of Finnish under-19 players is 38.32 cm with a range of 32.55 - 43.61 cm (N=19).

In the 20-meter sprint test for Finnish outfield players (N=22), the average time is 3.099 s, with a range of 2.826 - 3.303 s. For goalkeepers (N=5), the average time is 3.172 s, with a range of 3.017 - 3.390 s. In Jiménez-Reyes' (2019) study of 39 Spanish elite players, the average time for the 20-meter sprint was 3.36 ± 0.09 s. Nakamura (2016) reported an average time of 3.05 ± 0.10 s for eighteen Brazilian elite players, Naser (2016) found an average time of 2.99 ± 0.04 s for eight elite players from New Zealand, and Nikolaidis (2019) reported an average time of 3.18 ± 0.17 s for sixteen elite players from Greece.

For Finnish goalkeepers (N=10), the standing broad jump without a run has an average distance of 242.2 cm, with a range of 226 - 266 cm. The corresponding values for outfield players (N=47) are an average of 243.59 cm, with a range of 209 - 286 cm.

For Finnish outfield players (N=36), the 1-legged lateral broad jump with the right leg has an average of 206.83 cm, with a range of 180 - 236 cm, and with the left leg 209.30 cm, with a range of 180 - 233 cm. Goalkeepers (N=8) have an average of 205.75 cm with the right leg, ranging from 195 - 236 cm and with the left leg 206.62 cm, ranging from 195 - 238 cm.

Table 2. The power and speed test results

Test	N =	Subgroup	Average value	Range	Median	Mode	Standard deviation
Countermovement jump (CMJ)	19	All together	38.32 cm	32.55 - 43.61 cm	38.77 cm	39.44 cm	3.07
20 m Sprint	22	Field players	3.099 s	2.826 - 3.303 s	3.143 s	3.22 s	0.12
	5	Goalkeepers	3.172 s	3.017 - 3.390 s	3.144 s	3.144 s	0.12
Standing Broad Jump	47	Field players	243.59 cm	209 - 286 cm	239 cm	234, 251 cm	18.58
	10	Goalkeepers	242.2 cm	226 - 266 cm	240.5 cm	238 cm	11.62
1-Leg Lateral Broad Jump	36	Field players Right Leg	206.83 cm	180 - 236 cm	203 cm	200, 220 cm	13.84
	36	Field players Left Leg	209.30 cm	180 - 233 cm	209 cm	200, 212 cm	11.66
	8	Goalkeepers Right Leg	205.75 cm	195 - 236 cm	200 cm	198, 200 cm	13.02
	8	Goalkeepers Left Leg	206.62 cm	195 - 238 cm	205 cm	195, 206 cm	12.80

5.3 Test results of maximum strength

Regarding strength testing, Vieira (2016), De Lira (2017) and Nunes (2018) investigated the strength levels of soccer players using an isokinetic dynamometer to measure the strength of the quadriceps and hamstrings. Vieira and Nunes studied Brazilian professional futsal players, while De Lira's subjects were Brazilian players involved in futsal, soccer, and beach soccer. The average strength levels obtained were 223.9 ± 33.4 N for the quadriceps and 128 ± 27.6 N for the hamstrings.

The dynamometer measurements correlated well with 1RM testing for both the quadriceps-squat and hamstrings-deadlift relationships (Najiah 2021). Either of these tests can be effectively used when choosing a test.

In Cuadrado Peñafiel's (2014) study, the 1RM deep squat of Spanish professional players was tested using a Smith machine. The average for the group of twelve players was 94.73 ± 17.01 kg.

For Finnish field players, the results for the deep squat (using only the bar and additional weights, not a Smith machine) had an average of 105.23 kg (N=43) with a range of 70-160 kg. Goalkeepers (N=9) had an average of 112.22 kg, with a range of 70-150 kg.

The results for Finnish field players (N=17) in hip thrust were an average of 200 kg, with a range of 140-230 kg. Goalkeepers (N=4) had an average of 200 kg, with a range of 180-230 kg.

For Finnish goalkeepers (N=6), the average deadlift was 114.16 kg, with a range of 75-150 kg. Field players (N=24) had an average of 123.54 kg, with a range of 90-170 kg. In the trap bar deadlift, the overall average among all players (N=16) was 151.0 kg, with a range of 106-196 kg.

Table 3. The maximum strength results

Test	N =	Subgroup	Average value	Range	Median	Mode	Standard deviation
Deep Squat	43	Field players	105.23 kg	70-160 kg	100 kg	100 kg	18.39
	9	Goalkeepers	112.22 kg	70-150 kg	110 kg	95 kg	25.06
Hip Thrust	17	Field players	200 kg	140-230 kg	200 kg	180, 210 kg	24.49
	4	Goalkeepers	200 kg	180-230 kg	195 kg	180 kg	21.21
Deadlift	24	Field players	123,54 kg	90-170 kg	120 kg	120 kg	20.07
	6	Goalkeepers	114.16 kg	75-150 kg	117.5 kg	110, 125 kg	24.39
Trap Bar	16	All together	151.0 kg	106-196 kg	136 kg	136 kg	24.74

Ultimately, in football, it has been observed that the speed and power characteristics of players, such as the countermovement jump and knee extension strength, are linked to the team's success (Arnason 2004). Therefore, it is important to start developing strength and power with young athletes sooner than later.

6. DISCUSSION

Based on the test results of Finnish national futsal team players under the age of 19, as well as the available research literature on the subject, it can be stated that the performance of Finnish youth is at a high level when compared to tested elite players from Spain, Brazil, Greece and New Zealand, to the extent that test data is available. It is noteworthy that the young participants in the tests are transitioning to the national elite level, so it can be assumed that the level of performance will likely increase, assuming that the training content for the development of different attributes remains of high quality.

The high physical performance of young Finnish national team players can be attributed to the support provided by the national team. When a player joins the national team training, they have the opportunity for individualized physical training. In the case of national team players, internal motivation is inherently high, which has been reflected in the improvement of test results from one national team camp to another.

Finland under 19 national team qualified 2023 for the first time ever to UEFA Under-19 Futsal Euro 2023. One of the reasons that Finland is in the top 8 nations in Europe is our physical performance level. The players are relatively fast, strong and endure. In futsal, physical performance is just one component of prediction of success in the sport. Achieving success also requires skill, tactical ability, quick decision-making and other components.

The knowledge base emphasized futsal game analysis, particularly the physical player-specific requirements of the sport. The selection of tests is justified from the perspective of the essential movement directions in futsal and the muscle groups of the lower extremities involved. The research results presented in this thesis can be applied to the physical training exercise choices, testing and goal-setting for futsal players. However, the most crucial aspect is to generate interest among players and coaches in physical training because the development of the game is strongly linked to faster and stronger players. Therefore, we need more education and quality research about the players'

physical performance.

The tests should be easy to conduct, and they should have an observable connection to the movements in the sport. Especially for young players, in the case of strength tests, it is emphasized that the test movement itself is the same as the training movement. This way, players also learn useful strength exercises. The future vision is to organize regional testing events where the entire set of tests for both strength and speed can be conducted on the same day. It is important that players are tested when as well-rested as possible, if possible. Factors related to reliability have been assessed. The tests used in the thesis are easily replicable and the metrics are valid. Reliability may be slightly compromised by the tester's subjective judgment in evaluating the criteria of strength tests and the possibility of measurement errors when assessing jump lengths.

More information about the performance of futsal players is increasingly needed, as it can contribute to creating higher-quality training that better meets individual needs. It would be desirable for speed and strength training to receive the recognition it deserves in the training culture of futsal, as solely practicing the sport does not address the developmental needs of these two important attributes. The futsal community should keep their mind open and use scientific research as a tool to provide the highest quality of training.

Furthermore, the test battery needs to be updated and developed to answer the most important movement directions in the game. The test battery at the moment is far from perfect and many thoughts came into mind during and after the testing process. To be able to develop better players, we need to emphasize more force production via maximum strength and speed training instead of endurance based training methods. In addition, the vision of the future is to gather more detailed information about different groups such as women and men at the elite level.

The good scientific practice was well realized as the test results were reported with honesty, integrity and accountability. Research methods such as 1

repetition maximum strength tests and speed related tests were based on scientific evidence, which makes them reliable tools to use. No conflict of interest is reported.

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