COMPARISON OF SKILLS AND LOWER LIMB BIOMECHANICS OF FEMALE FUTSAL PLAYERS AT COLLEGIATE AND CLUB LEVELS

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Abstract

This study was conducted to compare the futsal-specific skills and biomechanical characteristics of futsal female players at collegiate and club levels. Ten collegiate and ten club level female futsal players voluntarily participated in the study. Four futsal-specific skills tests (i.e., Massey Futsal Shooting Test, Illinois Agility Test, 20m sprint test and Futsal Intermittent Endurance Test) and four lower limb biomechanical tests (i.e., Drop Vertical Jump, Counter Movement Jump, Star Excursion Balance Test and isokinetic strength and power at 60°/s and 300°/s of knee flexors and extensors) were completed by the participants. Anthropometric parameters such as body weight, standing height and body fat composition were collected. An independent T-test was used to to determine the mean differences across groups in all variables. Results showed that there were no statistically significant differences between both groups except for MFST (p value = 0.00). The shot speed for the club group was statistically faster (52.16 $km.h^{-1}$) than the collegiate group (43.44 $km.h^{-1}$). The duration to complete the shots for club group was statistically shorter (4.35s) than collegiate group (4.43s). More total scores were obtained by the collegiate group (4.43 point) than the club group (4.35 point). These results conclude that both groups had similar level of strength and power for the lower limb, except for shooting skill. Training should focus on strength development for hamstring and quadriceps muscles because these muscles may affect shooting speed in both collegiate and club players.

Keywords: Futsal, skills; intermittent running, agility, sprinting, shooting, biomechanics; jumping, balancing, strength and power

Introduction

Futsal is the indoor version of soccer that is growing in popularity all over the world. Since 1989, futsal world championships have been contested by many national teams every four years (Castagna, D'Ottavio, Vera & Álvarez, 2009). Nowadays futsal is played at the recreational, amateur, and professional levels with male and female championships contested all over the world (Barbero-Alvarez, Soto, Barbero-Alvarez & Granda-Vera, 2008).

Despite the growing interest in futsal performance, information related to training and physical demands of matches were focused mainly on elite male players (Ali, Williams, Hulse, Strudwick, Reddin, Howarth, Eldred, Hirst, & McGregor, 2007; Barbero-Alvarez et al., 2008; Castagna et al., 2009; Naser & Ali, 2016). Moreover, previous studies have focused more on game analysis or the physiological demands of small-sided versions of soccer played at recreational level (Barbero et al., 2008; Castagna, Belardinelli, Impellizzeri, Abt, Coutts & D'Ottavio, 2007) instead of futsal. However, information on performance characteristics, skills and lower limb biomechanics in female futsal players are of great interest to coaches and sport scientists (Krustrup, Mohr, Amstrup, Rysgaard, Johansen, Steensberg, Pedersen, & Bangsbo, 2003). Studies on lower limb biomechanics are suggested to evaluate the risk of injuries in female futsal players particularly at the knee joint. The benefit of comparing the risk of injuries between club and collegiate players is that we can recognize which level will have a greater risk of injuries.

Since futsal involves irregular movements like jumping, accelerating and stopping, and tackling along the game play, the risk of injuries may be increased (Cain, Nicholson, Adams, & Burns, 2007). For example, the risk of anterior cruciate ligament (ACL) injuries can be predicted through the drop vertical jump test (Hewett, Myer, Ford, Heidt, Colosimo, McLean, Van den Bogert, Paterno, & Succop, 2005; Noyes, Barber-Westin, Fleckenstein, Walsh, & West, 2005). Furthermore, Noyes et al., (2005) used 2D kinematic analysis in their study for evaluating the value of training and intervention programs in reducing frontal-plane dynamic knee valgus.

Comparative analysis will provide an objective assessment of player demands and enables researchers to investigate physical performance, skill and biomechanics required to play the game at different competitive levels. Furthermore, from a player's fitness profile, a coach can adapt the appropriateness of the training program to improve on players' performance. Therefore, the purpose of this study was to compare the futsal-specific skills and biomechanical characteristics of futsal female players at collegiate and club levels.

Methods

Participants

10 collegiate and 10 club level female futsal players were recruited. Approximately, two days were required for data collection among the participant, including familiarisation

session prior to the experiments. The study was approved by the Human Research Ethics Committee of a local university (USM/JEPeM/16090324). The study protocol was in compliance with the Declaration of Helsinki 1975. All participants and their legal guardians were informed of the experimental procedures. Upon agreement, their signed consent forms were obtained. All participants voluntarily participated.

Study Design

A cross-sectional study design was adopted to compare futsal-specific skills and lower limb biomechanical variables in female futsal players of different competitive levels. Four futsal-specific skills tests (i.e., Massey Futsal Shooting Test, Illinois Agility Test, 20m sprint test and Futsal Intermittent Endurance Test) and four lower limb biomechanical tests (i.e., Drop Vertical Jump, Counter Movement Jump, Star Excursion Balance Test and isokinetic strength and power of knee flexors and extensors) were completed by the participants.

Prior to the tests, the anthropometric parameters such as body weight, standing height and body fat composition were obtained. A portable stadiometer (Seca 220, Germany) was used to measure the height of the subjects. The body weight and body composition were measured by using Body Composition Analyzer (TANITA, model TBF-410, Japan). During the measurement, participants wore light clothing and were barefoot.

Study Procedure

Massey Futsal Shooting Test (MFST)

MFST is a reliable and valid protocol to assess futsal shooting-skill performance (Naser & Ali, 2016). First, the futsal ball was placed on the marked circle located at the centre of the shooting zone. Participants stood 11 metres from the ball. Upon a call by the investigator, participants sprinted to the ball, played a rebound pass off to the bench, controlled the ball, turned and shot at the goal within the shooting zone. The stopwatch was started from the initial call and was stopped as the participants struck the ball. Participants were given five shots for each foot and each score and ball speed were recorded. Ball speed was evaluated using Bushnell 101911 Velocity Speed Gun (Bushnell, Brooklyn, New York, United States). The setup and procedure of MFST followed previous study conducted by Naser & Ali (2016).

20m Sprint Test

The 20m sprint test is a common test used to assess lower body power and acceleration from a stationary position in futsal players (Gorostiaga, Llodio, Ibanez, Granados, Navarro, Ruesta, & Izquierdo, 2009). This test started from the starting line with a standing stance. Participants sprinted for 20m as fast as they could. Then, they repeated the test for three trials with a 60s active recovery period provided between the trials by walking back to the starting line.

Illinois Agility Test (IAGT)

IAGT is a valid and reliable test to evaluate agility in team sports (Hachana, Chaabène, Nabli, Attia, Moualhi, Farhat, & Elloumi, 2013). Participants sprinted 9.20m, turned, and returned to the starting line after receiving a command. After returning to the starting line, Participants swerved in and out of four cones, completed two 9.20m sprints to complete the agility course. The time of completion was recorded and the tests were repeated for three trials. The setup and procedure of IAGT followed previous study conducted by Hachana et al., (2013).

Futsal Intermittent Endurance Test (FIET)

FIET was used to assess specific high-intensity endurance in well-trained male and elite female futsal players by referring to the estimated VO_2 max (Barbero-Alvarez, Subiela, Granda-Vera, Castagna, Gómez & Del Coso, 2015). The tests were conducted at progressively increasing speeds interspersed with passive rest of 10–30s, until exhaustion. The FIET consisted of six blocks. Each block was made up of eight bouts of 3 × 15-m shuttles (except for the first block which has nine bouts) of progressively increasing speeds. This test started with the first block, in which, subjects began the test with running speed at 9 km/h in the first bout and increased progressively by 0.2 km/h for each bout in each block until they completed all the blocks. The tempo was controlled by audio beeps from an MP3 player by referring to the beep time table. The setup and procedure of FIET followed previous study conducted by Barbero-Alvarez et al., (2015).

Isokinetic strength and power of knee flexors and extensors test

Before the test began, participants performed a five-minute warm up on a cycle ergometer (H-300-RLode, Groningen, Holland) at 25 W and 50 RPM. The warm up was focused on hamstring and quadriceps. Leg dominance was determined by asking the participant on the preferred limb when kicking a ball. After the warm up session, participants were seated on the isokinetic dynamometer with their hips flexed, and standard stabilisation strapping was placed across the trunk, waist, and distal femur of the limb being tested. The axis of the dynamometer was aligned with the lateral femoral condyle, while the knees were flexed at 90º. The participants then performed a maximum of five repetitions of knee extension/flexion at angular velocities of 60°/s and 300°/s in both legs. Velocity at 60° was used to access strength while velocity at 300° was used to access power of the knee flexors and extensors. Consistent verbal motivation was given to ensure that participants performed the test with maximal effort.

Star Excursion Balance Test (SEBT)

SEBT was shown to be as a valid and reliable test to assess dynamic balance (Bastien, Moffet, Bouyer, Perron, Hébert, & Leblond, 2014). The testing grid consisted of eight lines, each 120 cm in length extending from a common point at 45° angle increments. The eight lines were labelled anterolateral (AL), anterior (ANT), anteromedial (AM), medial (MD), posteromedial (PM), posterior (PO), posterolateral (PL), and lateral (LAT). The middle of the grid was marked with a small dot that indicated the place to put the stance foot over during testing. Performance on the SEBT was quantified by measuring the distance reached with the contralateral leg, and greater reach distance was associated with greater postural control.

Participants performed the test with their dominant leg first. Their first position was at the centre with barefoot single leg stance. Once the researcher gave order of direction, participants then touched along the chosen line as far as possible using their contralateral leg. Participants were not allowed to use the reach foot as a support in the maintenance of upright posture. Then, participants returned to a bilateral stance while maintaining their equilibrium. The examiner marked the point touched along the line and measured the distance in cm from the centre of the grid to the touch point with a measuring tape. The order of reach directions followed a clockwise direction in order to avoid confusion while collecting the data.

Before testing, participants were given three minutes to familiarise themselves with the SEBT grid and were asked to practice reaching in each direction. Each participant performed three practice trials for each direction on each leg followed by 5 minutes of rest before test began. Participants then performed 3 trials in each direction on each limb. Ten seconds of rest were provided between individual reach trials. The distance reached data were normalised to the participants' leg length. The ratio was then expressed as percentage. This normalisation of SEBT scores is crucial to avoid calculation bias due to the length of participants' leg. The setup and procedures of SEBT followed a previous study conducted by Gribble & Hertel (2003).

Drop Vertical Jump (DVJ) Test

A DVJ test was used to evaluate dynamic knee valgus (Munro, Herrington, & Carolan, 2012). The test started with participants standing with feet shoulder-width apart on a box with 30cm height. They were instructed to lean forward and drop from the box as vertically as possible, then immediately performed a maximal vertical jump, and finally landing back on the force plate. There were no instructions regarding arm movement and participants performed the jump naturally. Each participant performed three DVJs starting from a standing position, with a one-minute rest interval. The jumps were captured from frontal plane using digital camera (SONY HDR-CX240), Japan) and further analysed using Siliconcoach Pro v.8 (The Tarn Group, UK). The normal range of knee frontal plane projection angle (FPPA) during landing from DVJ test for females is 7° to 13° (Munro et al., 2012).

Counter Movement Jump (CMJ) Test

A CMJ test was used to evaluate maximum explosive power of the lower limb. Participants were asked to keep hands on their hips to prevent influence of arm movements on vertical jumps and to squat down to approximately 90° and then immediately extended the knees and hip to jump as high as possible. Participants were also asked to take-off from both feet with no initial shuffling or steps and not to pause at the base of the squat. Each participant performed three maximal CMJs starting from a standing position, with a one-minute rest interval. The mean of the three jumps was used as the performance score.

Statistical Analyses

The data were analysed using the Statistical Package for the Social Sciences (SPSS) version 22.0 (IBM Corp, New York, US). Independent T-Test was applied to determine the mean differences across groups in all variables. Then, results of both groups (N = 20) were combined and analysed using Pearson correlation to determine the relationship of skills, lower limb biomechanics and shooting speed. Th level of significance was set at p<0.05 per statistical convention.

Results

Descriptive statistics of participants' physical characteristics are presented on Table 1. Independent T-test revealed that there were statistically significant differences of age (t=-2.85, df=18, p value = 0.01) and body weight (t=2.24, df=17, p value = 0.04) between collegiate and club groups. However, there were no statistically significant differences across groups on body fat percentage (t=0.65, df=18, p value= 0.53), height (t=0.3, df=17, p value= 0.77), body mass index (BMI) (t=1.79, df=17, p value= 0.09), standing (right side) (t=0.58, df=17, p value= 0.57), lying (right side) (t=-0.23, df=17, p value= 0.82), standing (left side) (t=0.43, df=17, p value= 0.67) and lying (left side) (t=0.43, df=17, p value= 0.68).

Table 1: Physical characteristics of the participants (N = 20)

Variables	Group		p value
	Collegiate (n = 10) (mean ± SD)	Club (n = 10) (mean ± SD)	
Age (years)	22.8 ± 1.4	24.5 ± 1.27	0.01*
Body Weight (kg)	56.0 ± 5.8	46.6 ± 15.4	0.04*
Body fat (%)	19.6 ± 1.7	19.1 ± 2.1	0.53
Height (cm)	157.1 ± 6	156.4 ± 3.0	0.77
Body Mass Index (BMI) (kg/m^2)	22.6 ± 1.3	21.3 ± 1.2	0.09
Standing leg length (right side) (cm)	84.5 ± 3.9	83.7 ± 1.6	0.57
Lying leg length (right side) (cm)	84 ± 4.5	84.3 ± 2.2	0.82
Standing leg length (left side)	84.1 ± 4.1	83.4 ± 2.0	0.67
Lying leg length (left side) (cm)	84.9 ± 5.7	84.1 ± 2.1	0.68

* = p value < 0.05, cm = centimetre, kg = kilogram, % = percentage

The endurance levels of the participants are presented on Table 2. Final block is the final level in FIET that the participants reached. Each block consists of bouts (e.g., sub-level), so the final bout means the last sub-level that the participant had reached. Total duration is the total time taken by the participants to complete FIET.

Table 2: Comparison of final block, final bout and duration between collegiate and club female futsal players in Futsal Intermittent Endurance Tests (FIET) (N =20)

Stages	Group		p value
	Collegiate (n=10) (mean ± SD)	Club (n=10) (mean ± SD)	
Block	1.10 ± 0.32	1.20 ± 0.42	0.56
Bout	5.60 ± 2.17	5.60 ± 2.22	1.0
Duration (minutes)	1.643 ± 0.68	1.89 ± 0.76	0.46

Independent T-test revealed that there were no statistically significant differences of final block reached (t=-0.68, df=18, p value=0.56), final bout reached (t=0, df=18, p value=1.0) and duration (t=-0.76, df=18, p value=0.46) between the collegiate and club groups.

Figure 1 shows the average duration to complete all the trials taken of both groups (collegiate: 18.44 ± 1.02s; club: 18.04 ± 0.44s) to complete Illinois Agility Test. Independent T-tests revealed that there were no statistically significant differences of the time to IAGT completion across groups (p=0.27, t=1.15, df=12.28).

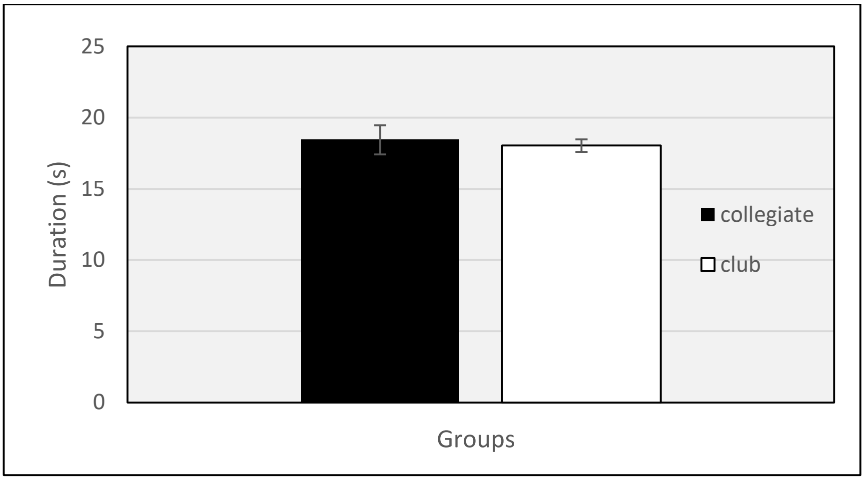

Figure 1: Comparison of the duration taken to complete Illinois Agility Test (IAGT) between collegiate and club female futsal players (N =20)

Figure 2 shows the duration taken to complete 20m sprint test of both groups (collegiate: 3.92 ± 0.21s; club: 3.95 ± 0.38). Independent T-test revealed that there were no statistically significant differences of time taken to complete 20m sprint between collegiate and club players (p=0.81, t=-0.24, df=18).

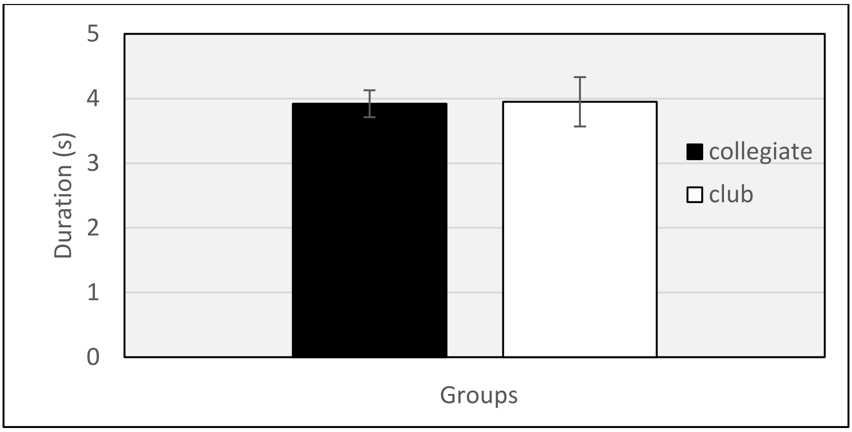

Figure 2: Comparison of the duration taken to complete 20m sprint test between collegiate and club female futsal players

Shooting is one of the most important skills in futsal. In this study, shooting skill was evaluated using the Massey Futsal Shooting Test (MFST). Shot speed and duration taken to make the shot were averaged from five trials that successfully reached on target (Table 3). Total scores referred to sum of scores that reached target. An independent T-test revealed that there were statistically significant differences between collegiate and club groups in shot speed (p=0.001, t=-13.28, df=8), duration to complete the shot (p=0.001, t=4.67, df=8) and total scores (p=0.001, t=4.70, df=8).

Table 3: Comparison of shot speed, duration and total scores between collegiate and club female futsal players (N = 20)

Variable	Group		p value
	Collegiate (n=10) (mean ± SD)	Club (n=10) (mean ± SD)	
Shot speed (km/h)	43.44 ± 0.92	52.16 ± 1.14	0.001*
Duration (s)	4.43 ± 0.03	4.35 ± 0.03	0.001*
Total scores	4.43 ± 0.03	4.35 ± 0.03	0.001*

* = *p* value < 0.05, km = kilometre, hr = hour, s = seconds

Dynamic balance of collegiate and club female futsal players were evaluated using Star Excursion Balance Test (SEBT). Table 4 showed the average distance reached for three trials of each eight positions that were tested. Nineteen participants were right leg dominant and only one was left leg dominant. Independent T-tests revealed that there were no statistically significant differences in all eight directions of SEBT for both legs between collegiate and club groups.

Table 4: Comparison of distance reached in eight directions of Star Excursion Balance Test between collegiate and club female futsal players (N = 20)

Direction of reach	Group		p value	t statistic
	Collegiate (n=10) (mean ± SD)	Club (n=10) (mean ± SD)		
RANT	126.28 ± 14.94	131.36 ± 17.15	0.49	-0.71
RAL	116.88 ± 10.63	119.96 ± 12.82	0.57	-0.59
RLAT	95.71 ± 13.54	96.11 ± 11.62	0.94	-0.07
RPL	106.02 ± 8.28	110.06 ± 5.24	0.21	-1.31
RPO	106.87 ± 14.71	111.60 ± 14.71	0.48	-0.72
RPM	118.78 ± 14.14	124.64 ± 16.64	0.41	-0.85
RMD	120.64 ± 17.0	126.10 ± 20.44	0.53	-0.65
RAM	125.40 ± 17.77	132.85 ± 16.51	0.34	-0.97
LANT	129.76 ± 20.43	134.47 ± 21.40	0.62	-0.5
LAM	131.08 ± 20.32	137.57 ± 20.01	0.48	-0.72
LMD	129.55 ± 16.71	137.12 ± 15.76	0.31	-1.04
LPM	123.91 ± 21.22	132.38 ± 20.55	0.38	-0.91
LPO	118.63 ± 18.97	123.27 ± 16.92	0.57	-0.58
LPL	107.22 ± 13.12	110.21 ± 10.45	0.58	-0.57
LLAT	100.04 ± 12.56	100.97 ± 8.78	0.85	-0.19
LAL	127.10 ± 18.78	232.80 ± 102.01	0.32	-1.03

RANT = Right anterior, RAL = Right anterolateral, RLAT= Right lateral, RPL = Right posterolateral, RPO = Right posterior, RPM = Right posteromedial, RMD = Right medial, RAM = Right anteromedial, LANT = Left anterior, LAM = Left anteromedial, LMD = Left medial, LPM = Left posteromedial, LPO = Left posterior, LPL = Left posterolateral, LLAT = Left lateral and LAL Left anterolateral.

Two dimensional of frontal plane projection angle (FPPA) of the knee joint were evaluated during drop vertical jump test (DVJ) in order to observe dynamic knee valgus. Figure 3 shows the static knee FPPA for both groups (collegiate: 6.9 ± 1.2°; club: 8.1 ± 1.79°). Independent T-test revealed that there were no statistically significant differences of average static knee FPPA between collegiate and club players (p=0.10, t=-1.76, df=18).

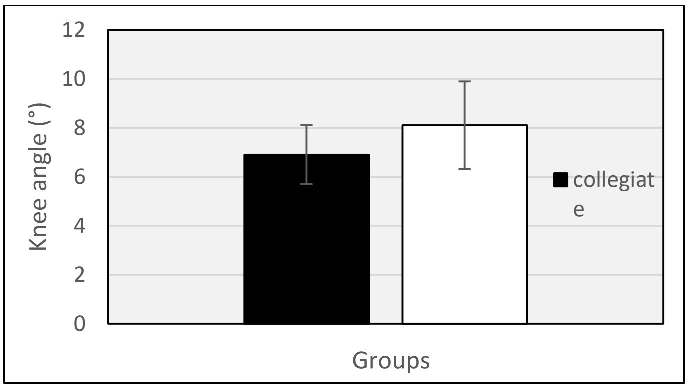

Figure 3: Comparison of static knee FPPA between collegiate and club female futsal players (N=20)

Figure 4 shows the knee FPPA during landing from DVJ test of both groups (collegiate: 14.1° ± 4; club: 11.74° ± 3.93). Independent T-test revealed that there were no statistically significant differences of average knee FPPA during DVJ Test between collegiate and club groups ($p=0.21$, $t=1.32$, $df=18$).

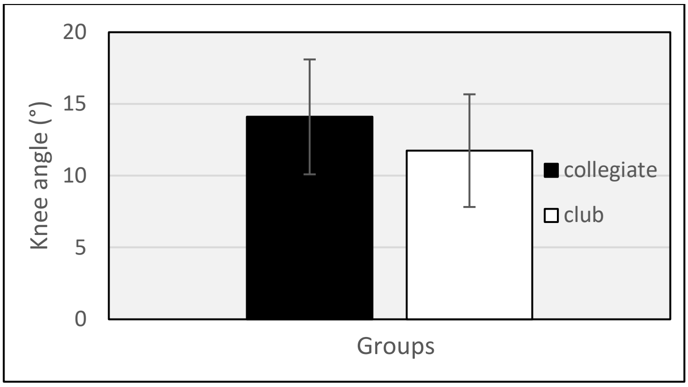

Figure 4: Comparison of knee FPPA during landing from DVJ test between collegiate and club female futsal players (N=20)

Peak torque per body weight (PT/BW) at 60°/s is an indicator of muscular strength, while torque at 300°/s is an indicator of muscular power. Table 5 shows the knee PT/BW of the dominant and non-dominant leg tested at 60°/s at sagittal plane (i.e., flexion and extension) for both groups. Independent T-test revealed that there were no statistically significant differences of knee PT/BW of the dominant and non-dominant leg tested at 60°/s at sagittal and ratio of knee extension PT/BW to flexion PT/BW of dominant leg (KH:Q DL) and non-dominant leg (KH:Q NDL) between collegiate and club groups.

Table 5: Comparison of knee PT/BW of the dominant and non-dominant leg tested at 60°/s at sagittal plane (i.e., flexion and extension) between collegiate and club female futsal players (N = 20)

Variable (PT/BW)	Group: Collegiate (n=10) (mean ± SD)	Club (n=10) (mean ± SD)	p value	t statistics
AKEXDL	231.8 ± 54.90	210.83 ± 53.55	0.42	0.84
AKEXNDL	214.74 ± 46.74	232.03 ± 53.26	0.45	-0.77
AKFXDL	124.00 ± 18.82	116.36 ± 14.59	0.32	1.02
AKFXNDL	124.17 ± 21.03	114.65 ± 17.32	0.28	1.11
KH:Q DL percentage (%)	62.30 ± 17.28	54.20 ± 18.98	0.33	1
KH:Q NDL percentage (%)	57.7 ± 10.56	51.8 ± 11.63	0.25	1.19

PT/BW = Peak Torque per Body Weight, AKEXDL = Average knee extension of dominant leg, AKEXNDL = Average knee extension of non-dominant leg, AKFXDL = Average knee flexion of dominant leg and AKFXNDL = Average knee flexion of non-dominant leg, KH:Q DL = Ratio of knee extension PT/BW to flexion PT/BW of dominant leg, KH:Q NDL = Ratio of knee extension PT/BW to flexion PT/BW of non-dominant leg.

Table 6 shows the knee PT/BW of the dominant and non-dominant leg tested at 300°/s at sagittal plane (i.e., flexion and extension) for both groups. Independent T-tests revealed that there were no statistically significant differences of knee PT/BW of the dominant and non-dominant leg and ratio of knee extension PT/BW to flexion PT/BW of dominant leg (KH:Q DL) and non-dominant leg (KH:Q NDL) at 300°/s at sagittal plane between collegiate and club groups.

Table 6: Comparison of knee PT/BW of the dominant and non-dominant leg tested at 300°/s at sagittal plane (i.e., flexion and extension) between collegiate and club female futsal players (N = 20)

Variable (PT/BW)	Group: Collegiate (n=10) (mean ± SD)	Group: Club (n=10) (mean ± SD)	p value	t statistics
AKEXDL	138.70 ± 54.69	141.30 ± 60.43	0.92	-0.1
AKEXNDL	154.77 ± 53.01	156.85 ± 37.41	0.92	-0.1
AKFXDL	121.24 ± 26.13	121.99 ± 27.16	0.95	-0.06
AKFXNDL	132.92 ± 18.71	116.75 ± 13.62	0.06	2.21
KH:Q DL percentage (%)	95.4 ± 24.1	84.8 ± 22.95	0.33	1.01
KH:Q NDL percentage (%)	99.8 ± 35.77	77.9 ± 17.18	0.1	1.75

PT/BW = Peak Torque per Body Weight, AKEXDL = Average knee extension of dominant leg, AKEXNDL = Average knee extension of non-dominant leg, AKFXDL = Average knee flexion of dominant leg and AKFXNDL = Average knee flexion of non-dominant leg, KH:Q DL = Ratio of knee extension PT/BW to flexion PT/BW of dominant leg, KH:Q NDL = Ratio of knee extension PT/BW to flexion PT/BW of non-dominant leg.

Figure 5 shows the jump height (cm) during CMJ test between collegiate (33.69 ± 4.34cm) and club (34.00 ± 2.62cm) female futsal players. Independent T-test revealed that there were no statistically significant differences of jump height between collegiate and club ($p=0.85$, $t=-0.19$, $df=18$).

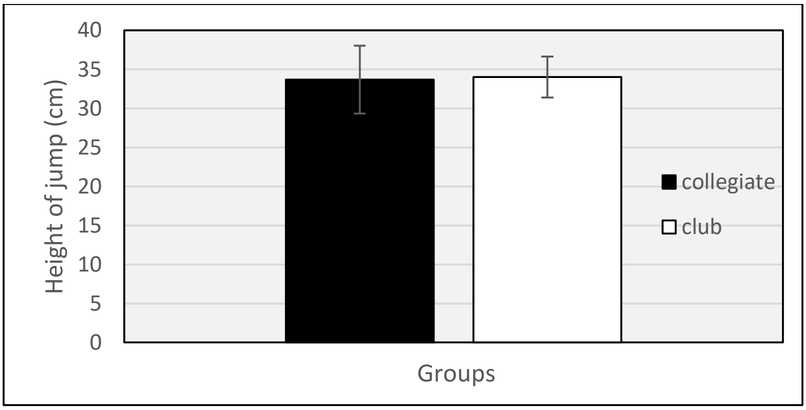

Figure 5: Comparison of jump height during counter movement jump test between collegiate and club female futsal players.

Discussions

The only variable that showed a statistically significant difference across groups was shooting skill (i.e., shooting speed, time taken to shoot a goal and total shooting scores). Club players had better shooting speed and manage to complete the shooting test in a shorter period of time although they have less total scores than the collegiate players. Scores were calculated based on the difficulty of making shots. For example, shot at the corner of the goal contribute five marks while shot at the centre of the goal contribute 1 mark. Club players showed better result of shot speed and duration to complete the shots compared to collegiate players. Meanwhile collegiate players showed better scores than club players. This means that a fast ball and quick time to complete the shot may not necessarily result in better scores. Moreover, the game pattern at the club level may be faster than the collegiate group; hence. we assume that the club players were conditioned to shoot the ball as soon as they get the chance. Our results are contrary to those of a a previous study by Naser & Ali (2016) in which the shot speed during MFST was 67km/h, 71km/h and 77km/h for social, semi-elite and elite male futsal players, respectively (Naser & Ali, 2016). However, there was no study among female futsal players that applied MFST for comparison.

In this study, 20 female futsal players were recruited and divided equally into two groups. which were collegiate and club group. Results showed that there were no differences of physical characteristics between both groups except for the body weight and age (Table 1). Most of the collegiate players were younger than club players since the range of age for collegiate students was between 19 to 24 years old. In term of body weight, club players were thinner than collegiate players. In a study by Thorpe & Ebersole (2008), 12 NCAA Division I collegiate female soccer student athletes were recruited with mean age 19.5 to 20 years old with body weight between 59 to 69 kg. The subjects of that study were heavier than our participants due to different type of population studied (i.e., Caucasian versus Asian).

Body fat percentage for collegiate players was 19.68 ± 1.76% and 19.11 ± 2.15% for club players. In a previous study, Barbero et al., (2015) noted that fourteen elite female futsal players had body fat percentage within 14.2% to 21%. In our study, both collegiate and club players had body fat percentage within the range as noted by Barbero et al., (2015).

In addition, the body height between both groups and other participants of previous studies also differed. Participants in a study by Thorpe & Ebersole (2008) were taller (157 to 180 cm) than our participants (151 to 163 cm). Furthermore, the leg length for both groups was 84.55 ± 3.98 cm for collegiate and 83.72 ± 1.62 cm for club. In a previous study, the average leg length was 81 to 87 cm for female collegiate soccer players (Bressel, Yonker, Kras & Heath, 2007).

In this study, the level of endurance for both groups was similar. Table 2 showed that most of the participants were unable to finish the first block of FIET. Castagna et al., (2009) reported that this may could be due to inability to perform change of direction at high intensity and to withstand with progressive high-intensity activity (i.e., anaerobic capacity) during FIET. In addition, it could be speculated that running over short distance (i.e., 15 m) at progressive speed and until exhaustion may heavily stress the neuromuscular system (Stølen, Chamari, Castagna & Wisløff, 2005).

In a study by Castagna et al., (2009) who recruited 18 full-time professional futsal players (gender not mentioned), the participants were able to reach until the last bout of the forth block in FIET with mean duration of eight minutes. The difference between this study and previous study was the level of participants which means that higher level of endurance is needed at higher level of futsal competition. Endurance is important in futsal. Even though the area of coverage is smaller than soccer, the nature of futsal itself requires players who can play a fast game, make quick decision and use the entire small area of coverage wisely.

Figure 1 showed that there were no differences of duration taken to complete the agility test between collegiate and club groups. Agility is required and important in futsal because futsal is a fast game and it is played in a small area and in a short time compared to soccer. Therefore, the ability to change direction or body position quickly in a short period of time is necessary. In a previous study, 105 male sports science students who actively involved in team sports (football, rugby and handball) completed the IAGT within 16.30 seconds (Hachana et al., 2013). On the other hand, female futsal players completed IAGT in 16.99 s while female soccer players completed IAGT in 17.5 s (Unveren, 2015). Compared to this study, our participants are considered less agile than the participants in the study by Unveren (2015) even though both participants at the same level which is university level. This might be due to two reasons: participants in the Unveren (2015) study had 6 years average of training age in futsal and their average age was 20 to 21 years old, while our participants had different background of sports and as long as they had represented university at least once, they were allowed to participate in this study.

Figure 2 showed that there were no differences in sprint speed across groups. In a previous study that applied the same test, elite male futsal players ran faster (average = 2.99 s) than social male futsal players (average = 3.16 s) (Naser & Ali, 2016). Furthermore, a previous study showed that female futsal players run faster (average = 2.98 s) than female soccer players (average = 3.30 s) (Unveren, 2015). Our participants ran slower than the participants in the study by Unveren (2015). Sprinting is important and very useful in futsal during counter attack and defends. According to Naser & Ali (2016), lower level players are less likely to sustain the frequent and short high-intensity sprinting actions that are required in futsal.

Table 3 showed that there were no differences of dynamic balance in all eight directions of SEBT for both legs between collegiate and club groups. This might be because both groups had same level of balancing ability. In futsal, dynamic balance is important during dribbling and shooting because these two skills were performed while moving. For most of the players in either collegiate or club groups, their preferred leg was right. Only two of the players preferred left leg.

In a previous study, soccer players and gymnasts had no difference in terms of static and dynamic balance but soccer players had better dynamic balance compared to basketball players (Bressel et al., 2007). This is because soccer players often perform single-leg reaching movements like passing, receiving, and shooting (Bressel et al., 2007). However, there was no study of dynamic balancing on futsal players using SEBT that can be compared to this study.

Results showed there were no differences of the static knee FPPA (Figure 3) and knee FPPA during landing from DVJ test (Figure 4) test for both groups. Static knee FPPA also known as Q-angle, can be measured from static standing position. Q-angle is the angle formed by two intersecting lines which were anterior superior iliac spine (ASIS) to mid patella and tibial tubercle to mid patella. Mean static knee FPPA (or Q-angle) of collegiate group was 6.9° while club group was 8.1°. Vanzeli, Reis, Pereira, Tavares & Fazan (2016) reported 17° is a normal value for Q-angle for females. Collegiate and club groups in this study showed that their Q-angles were less than 17º. So, both groups were not in normal range.

Furthermore, the average knee FPPA during landing from DVJ test for collegiate group was 14.1° while that for club group was 11.74° (Figure 4). Munro et al., (2012), stated that the normal range of knee FPPA during landing from DVJ test for females was 7° to 13°. Hence, the collegiate players were observed to land with more valgus position during DVJ compared to the club group, although the differences were not statistically significant.

Excessive dynamic knee valgus can lead to patellofemoral joint syndrome and anterior cruciate ligament (ACL) injury (Almeida, Carvalho, França, Magalhães, Burke & Marques 2016). Munro et al., (2012) stated that dynamic knee valgus happened with the combination of hip adduction, hip internal rotation, knee flexion, knee external rotation, knee abduction, ankle inversion. This is because of the weak part of the muscles at hip like hamstring and quadriceps. Therefore, coaches should focus on developing muscular strength, particularly around hip and knee joint, in female futsal players.

In this study, peak torque per body weight (PT/BW) was evaluated using isokinetic dynamometer. There were two velocities involved which were 60°/s and 300°/s. Velocity at 60°/s was used to assess strength while velocity at 300°/s was used to assess power of the knee flexors and extensors (Willigenburg, McNally & Hewett, 2014). Results showed there were no statistically significant differences of knee PT/BW of the dominant and non-dominant leg at 60°/s and 300°/s (Table 5 and 6) at sagittal plane between collegiate and club groups. This study showed that H:Q ratio for dominant and non-dominant leg at speed 60°/s and 300°/s were within normal range which was from 50% to 80%, depending on the knee angle and angular velocity (Rosene, Fogarty & Mahaffey, 2001). Data from a previous study by Calmels, Nellen, van der Borne, Jourdin, & Minaire, (1997) obtained from healthy volunteers showed that the ratio 55-60 % at the slow velocity 60º/s and 63% at fast angular velocity. Compared to the previous study, H:Q ratios of our participants for both speeds were still in range.

Figure 5 showed there were no statistically significant differences of jump height between collegiate and club female futsal players. Similarly, it was reported that there were no differences of jump height between elite, semi-elite and social groups of male futsal players (Naser & Ali, 2016).

Compared to a previous study, male social players in the study by Naser & Ali (2016) jump higher (47.3 cm ± 9.3) than our participants (Figure 5). This is because of the different gender of the participants. However, according to Payne, Slater, & Telford (1968), arm swinging during jump may produce extra force for the propulsion of the body. Contrary to our study protocol, participants were not allowed to swing their arms in order to get the actual reading of their ability in jumps. In futsal, jumping motion was more on arm swinging. However, CMJ was the best test to evaluate leg explosive power in futsal players.

There were several limitations in this study. First, two-dimensional (2D) motion captures were used in evaluating knee valgus. As we know, 2D analysis is lacking in providing the correct or actual values of knee FPPA compared to 3D analysis. Next, leg alignments such as varus and valgus were not quantified using its gold standard (e.g., radiographical assessment). Lastly, the actual sample size was small hence unable to represent both groups. Since studies regarding female futsal players are lacking, the strength of this study is the study itself in which we did a study on female futsal players and this study could be one of the reference sources for next researchers.

Conclusion

As a conclusion, our study showed that both groups were lacking in muscular strength, agility and endurance, which made them slower in sprinting, and had excessive dynamic knee valgus. Excessive dynamic knee valgus will lead to non-contact knee injuries for examples ACL and PFPS. Therefore, coaches and players are suggested to include more training sessions that focus on strength exercises for hamstring and quadriceps muscles and also hip muscles for injury prevention and performance enhancement. Besides that, it is also important to develop shooting skill among the collegiate players. This is because the difference between collegiate and club group lays primarily in their shooting skill.

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Conflicts of interest

None declared.

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