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# The Relationship between Balance Performance and Knee Flexor-Extensor Muscular Strength of Football Players

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**ABSTRACT** The aim of present study was to examine relationships between knee flexor-extensor muscular strength with respect to three different approach angles and balance performance of football players. A total of 33 male football players were tested using Technobody Isokinetic Balance Test System and CSMI Humac Norm Isokinetic Dynamometer. It was determined that there were significant negative correlations between knee flexor-extensor muscular strength and dynamic balance performance in the both dominant and non-dominant side of football players except for 240 degree/s. In addition, there were significant negative correlations between a lot of parameters examined for knee flexion-extension muscular strength and static balance performance in the both dominant and non-dominant side of football players. In conclusion, strengthening the muscles of players with isokinetic muscle strength exercise at this degrees/s is quite important for players in upgrading to the optimal level the static and dynamic balance values on their sporting performance.

## INTRODUCTION

The ability to balance is the most basic element of daily activity. Without doubt, postural stability is basic not only in daily-life situations but also in almost all sports (Cankaya et al. 2015). Balance, the process of maintaining the position of the body's center of gravity vertically over the base of support, is a key component in both the maintenance of functional abilities and performance of high level physical activity (Nashner 1997; Cankaya et al. 2015). Due to the high balance demands, sufficient balance abilities are especially important in physically demanding sports, such as football. Football is one of the most popular and demanding sports in the world. There is a need in the evaluation of sports performance for a static and dynamic standing balance measure to quantify balance ability in football players. Static balance is associated with maintaining body posture, whereas dynamic balance is associated with maintaining or regaining this state during motor activity (Witkowski et al. 2014). An effective postural control is especially important for the present and future performances of young soccer players (Paillard et al. 2006), as soccer requires a unipedal posture to perform many different technical movements (for example, shooting, passing).

The knee extensors are the prime movers involved in running, jumping and kicking the ball, whereas the knee flexors are involved in running where they influence stride length and stabilize the knee joint in changes of direction, acceleration and deceleration, and during landing (Stolen et al. 2005; Cerrah et al. 2011). Also, strength of the knee flexors and extensors and their ratios have also been identified as important parameters in prevention of injury of the knee and hamstrings (Proske et al. 2004; Hughes et al. 2006). For these reasons, strength and balance are basic elements of for daily functional movements. For studying the identification of knee extensors and flexors strength at different angular velocities in adult soccer players, isokinetic devices (for example, isokinetic dynamometry) are considered a good means (Cotte et al. 2011; Drid et al. 2011).

The relationship between balance ability and sport injury risk has been established in many cases, but the relationship between balance ability and athletic performance is less clear (Hrysomallis 2011). Also, in studies on balance, performance assessments related to age and sports branches are researched; however, the relationship between motoric features (strength, speed, mobility etc.) and balance performance is not

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adequately studied. When balance studies are considered from this point of view, researching and developing the variables which affect balance performance will develop performance as well.

### Purpose of the Study

The purpose of the present study is to investigate the relationship between knee flexor-extensor muscular strength and balance performance in amateur football players.

## MATERIAL AND METHODS

### Participants

A total of 33 male football players from three different departments (Departments of Sport Management, Physical Education and Sports, Coach Training) at the Yasar Dogu Sports Sciences Faculty of Ondokuz Mayis University, who were playing at Regional Amateur League of Samsun- Turkey and who had trained regularly at least for the last five years, aged between 17-23 (19.21±3.51 years) participated voluntarily.

### Data Collection Tools

In this study, two measurement tools were used. One of these is Technobody isokinetic Balance Test system used for measuring the balance performance (static and dynamic) of the football players. The other is CSMI Humac Norm Isokinetic Dynamometer used for measuring the knee flexor-extensor muscular strength of the football players. Muscle strength of the lower extremities in football players has been assessed using isokinetic peak torque (Oberg et al. 1986).

### Applications

The parameters were measured at Ondokuz Mayis University, Yasar Dogu Faculty of Sports Sciences Sports Laboratory.

### *Static and Dynamic Balance Measurements*

Static test was performed with double leg posture position on a fixed platform with eyes open and eyes closed in one leg (the position of the dominant (D) and non-dominant (ND) leg). In this 30 second- test protecting the position is requested and provided to the reagent to follow the position on the screen. Static balance measurements are Center of Pressure in the X-axis, Center of Pressure in the Y-axis ($DOE_{CoP-X}$: Center of pressure in the X-axis and in the position of the dominant leg with eyes open; $DOE_{CoP-Y}$: Center of pressure in the Y-axis and in the position of the dominant leg with eyes open; $DCE_{CoP-X}$: Center of pressure in the X-axis and in the position of the dominant leg with eyes closed; $DCE_{CoP-Y}$: Center of pressure in the Y-axis and in the position of the dominant leg with eyes closed, $BOE_{CoP-X}$: Center of pressure in the X-axis and in the bipedal position with eyes open; $BOE_{CoP-Y}$: Center of pressure in the Y-axis and in the bipedal position with eyes open, $BCE_{CoP-X}$**:** Center of pressure in the X-axis and in the bipedal position with eyes closed; $BCE_{CoP-Y}$: Center of pressure in the Y-axis and in the bipedal position with eyes closed, $NDOE_{CoP-X}$: Center of pressure in the X-axis and in the position of the non-dominant leg with eyes open; $NDOE_{CoP-Y}$: Center of pressure in the Y-axis and in the position of the non-dominant leg with eyes open; $NDCE_{CoP-X}$: Center of pressure in the X-axis and in the position of the non-dominant leg with eyes closed and $NDCE_{CoP-Y}$: Center of pressure in the Y-axis and in the position of the non-dominant leg with eyes closed).

Dynamic test was carried out with double leg posture position. Optimum position was determined like in the static test, feet wide apart as shoulder and feet posture open positions with reference to the lines on the x and y axis, so that it points equidistant from the point of the origin. Pressure level of stabilometer for this test are set according to the 5 (out of 50) degrees of difficulty. Following the circular route on the platform, the test was completed by turning it clockwise 5 rounds within 60 seconds. If individuals did not complete the test in valid time, the performance of the individual so far was taken as a result of the test. These measurements were taken one time (open eyes). The increase in dynamic balance scores indicated deterioration in the balance of the individual (Cankaya et al. 2015).

### *Knee Flexor-extensor Muscular Strength Measurements*

The HUMAC NORM System (CSMI, USA) was used to measure the isokinetic muscle function. The test objectives and protocol were stated clearly to the football players to obtain the best performance during the test.

Before each testing session, the dynamometer was calibrated in accordance with the manufacturer's recommendations. All football players started with a standardized warm-up consisting of 10-min of cycling (Monark) at 55-60 rpm against no load, and 5-7 minute of stretching. Following the warm-up, football players rested for 5-min.

Peak isokinetic concentric knee extension and flexion torque of both legs were evaluated at 3 angular velocities: 60, 180 and $240^0$/s. the knee extension and flexion contractions were performed through a range of 0 - $90^0$ (full extension defined as 0 degree). Football players were instructed to complete three submaximal trials at each angular velocity for familiarization and warm-up. Peak isokinetic concentric knee extension and flexion torque were measured from dominant and non-dominant legs with 60, 180 and $240^0$/s extension ($D_{EXT}60^0$/s-$ND_{EXT}60^0$/s; $D_{EXT}180^0$/s-$ND_{EXT}180^0$/s and $D_{EXT}240^0$/s-$ND_{EXT}240^0$/s, respectively) and flexion ($D_{FLX}60^0$/s-$ND_{FLX}60^0$/s; $D_{FLX}180^0$/s-$ND_{FLX}180^0$/s and $D_{FLX}240^0$/s-$ND_{FLX}240^0$/s, respectively). Football players then performed 10 maximal repetitions of knee extension and flexion at each selected angular velocity. A 30-s time interval was provided between familiarization and test session whereas a 2-min rest period was given between each test velocity. In addition, a break of at least 3-min was given when the machine setting was changed for the opposite leg (Atabek et al. 2009). The order of testing was randomized for the dominant and non-dominant legs. Verbal encouragements and visual feedback were given by investigator to all players to help them concentrate on the quality of their movements. The greatest peak torque (Nm) for knee extension and flexion (out of the 10 trials in each velocity) was calculated automatically by the HUMAC NORM System and served as the outcome measure.

## Ethical Considerations

Before the study, the required ethics committee approval by Ondokuz Mayis University (2014/567) and written permission of the consents of the participants were obtained. The aim of this study was explained to the subjects during the data collection phase, and thus the "informed consent principle" was fulfilled.

## Statistical Analysis

All the data analyses were performed using the Statistical Package for Social Sciences (SPSS) Version 11.0 (SPSS 2002). The Shapiro-Wilk test was performed to test normality assumption. Non-normally distributed data were expressed as sample size, mean and median values with interquartile range (IQR). The IQR is the 1st quartile subtracted from the 3rd quartile (IQR = $Q_3$-$Q_1$). Kendall's Tau b correlation coefficients were used to estimate the association between knee flexor-extensor muscular strength and balance performance in amateur football players. $P<0.05$ probability value was considered as significant.

## RESULTS

Static and dynamic balance measurements of the football players were presented as sample size (n), mean, median and interquartile range values in Table 1. Static balance measurements used in this study were $DOE_{CoP-X}$, $DOE_{CoP-Y}$, $DCE_{CoP-X}$, $DCE_{CoP-Y}$, $BOE_{CoP-X}$, $BOE_{CoP-Y}$, $BCE_{CoP-X}$, $BCE_{CoP-Y}$, $NDOE_{CoP-X}$, $NDOE_{CoP-Y}$, $NDCE_{CoP-X}$ and $NDCE_{CoP-Y}$.

**Table 1: The descriptive statistics for the balance scores**

| *Static and dynamic balance measurement variables* | *n* | *Mean* | *Median* | *IQR* |
|---|---|---|---|---|
| *Static Balance* | | | | |
| $DOE_{CoP-X}$ | 33 | 1.90 | 2.00 | 1.50 |
| $DOE_{CoP-Y}$ | 33 | 2.03 | 2.00 | 2.00 |
| $DCE_{CoP-X}$ | 33 | 3.00 | 3.00 | 2.00 |
| $DCE_{CoP-Y}$ | 33 | 3.42 | 3.00 | 1.00 |
| $BOE_{CoP-X}$ | 33 | 1.63 | 2.00 | 1.00 |
| $BOE_{CoP-Y}$ | 33 | 1.45 | 1.00 | 1.00 |
| $BCE_{CoP-X}$ | 33 | 3.06 | 3.00 | 2.00 |
| $BCE_{CopY}$ | 33 | 3.12 | 3.00 | 2.00 |
| $NDOE_{CoP-X}$ | 33 | 3.27 | 3.00 | 2.00 |
| $NDOE_{CoP-Y}$ | 33 | 3.24 | 3.00 | 1.00 |
| $NDCE_{CoP-X}$ | 33 | 4.75 | 5.00 | 2.00 |
| $NDCE_{CoP-Y}$ | 33 | 5.33 | 5.00 | 1.00 |
| *Dynamic Balance* | 33 | 0.93 | 0.49 | 1.00 |

The results of the present study showed that best balance scores of football players were found in eyes open both legs($BOE_{CoP-X}$=1.63, $BOE_{CoP-Y}$ =1.45) and dominant leg ($DOE_{CoP-X}$=1.90, $DOE_{CoP-Y}$ =2.03) preferences, whereas the worst scores were found in eyes closed ($NDCE_{CoP-X}$=4.75, $NDCE_{CoP-Y}$=5.33) and eyes open non-dominant (NDO-

$E_{CoP-X}$ =3.27, $NDOE_{CoP-Y}$ =3.24) leg preferences (Table 1).

At three angular velocities: 60, 180 and 240$^0$/s, the peak isokinetic concentric knee extension and flexion torque measurements ($D_{EXT}60^0$/s-$ND_{EXT}60^0$/s; $D_{EXT}180^0$/s-$ND_{EXT}180^0$/s and $D_{EXT}240^0$/s-$ND_{EXT}240^0$/s for extension; $D_{FLX}60^0$/s-$ND_{FLX}60^0$/s; $D_{FLX}180^0$/s-$ND_{FLX}180^0$/s and $D_{FLX}240^0$/s-$ND_{FLX}240^0$/s for flexion, respectively) from dominant and non-dominant legs of the football players were presented as sample size(n), mean, median and interquartile range values in Table 2.

**Table 2: The descriptive statistics for isokinetic extensor and flexor muscles strength at different three angular velocity**

| *Extension and flexion muscles strength of dominant and non-dominant leg at three angular velocity (Nm)* | *n* | *Mean* | *Median* | *IQR* |
|---|---|---|---|---|
| $D_{EXT}60^0$/s | 33 | 192.96 | 191.00 | 49.00 |
| $ND_{EXT}60^0$/s | 33 | 181.45 | 178.00 | 35.50 |
| $D_{FLX}60^0$/s | 33 | 124.48 | 122.50 | 42.00 |
| $ND_{FLX}60^0$/s | 33 | 113.03 | 116.00 | 42.50 |
| $D_{EXT}180^0$/s | 33 | 137.60 | 139.00 | 43.00 |
| $ND_{EXT}180^0$/s | 33 | 130.51 | 128.00 | 35.00 |
| $D_{FLX}180^0$/s | 33 | 95.63 | 91.00 | 35.50 |
| $ND_{FLX}180^0$/s | 33 | 87.54 | 86.00 | 40.50 |
| $D_{EXT}240^0$/s | 33 | 105.66 | 102.00 | 36.50 |
| $ND_{EXT}240^0$/s | 33 | 98.48 | 97.50 | 29.75 |
| $D_{FLX}240^0$/s | 33 | 79.84 | 81.00 | 21.50 |
| $ND_{FLX}240^0$/s | 33 | 71.69 | 73.00 | 23.50 |

Table 2 showed that in isokinetic extensor and flexor muscles strength, the highest scores were reached in smallest angles ($D_{EXT}60^0$/s=192.96, $ND_{EXT}60^0$/s=181.45, $D_{FLX}60^0$/s=124.48, $ND_{FLX}60^0$/s =113.03). It was further observed that isokinetic extension and flexion muscles strength (torque), measured from both the dominant and non-dominant leg, decreases as the rate of angular velocity increases (Table 2).

The correlations between the peak isokinetic knee extension and flexion torque measurements from dominant and non-dominant legs at three angular velocities: 60, 180 and 240$^0$/s and static-dynamic balance performance of football players were presented in Tables 3 and 4.

The results showed that there were generally significant negative correlations ranged from small to moderate level between the measurements of strength and the balance performance from dominant leg of football players at all angular velocities (Table 3). According to the dominant leg preference, negative significant differences were found between all other parameters except $DCE_{CoP-X}$, $NDCE_{CoP-X}$ and $NDOE_{CoP-Y}$ at 60° extension muscle strength; between $DOE_{CoP-X}$, $DOE_{CoP-Y}$, $NDOE_{CoP-X}$ and $NDOE_{CoP-Y}$ at 60° flexion muscle strength; between $DOE_{CoP-X}$, $DOE_{CoP-Y}$, $NDOE_{CoP-X}$ and $NDCE_{CoP-Y}$ at 180° extension muscle strengths; between $DOE_{CoP-X}$ and $DOE_{CoP-Y}$, $DCE_{CoP-Y}$, $NDOE_{CoP-X}$ and $NDOE_{CoP-Y}$ at 180° flexion muscle strength; between $DOE_{CoP-X}$ and $DCE_{CoP-X}$ and $NDOE_{CoP-X}$ and $NDCE_{CoP-Y}$ at 240° extension muscle strength and in only $DOE_{CoP-X}$ at 240° flexion muscle strength (Table 3). However, no significant relationships were generally determined between the measurements of peak isokinetic knee extension-flexion strength from dominant leg at three angular velocities: 60, 180 and 240$^0$/s except for $D_{EXT}60^0$/s and examined static balance in the bipedal position. Also, no significant relationship was observed between the measurements of $D_{FLX}240^0$/s and dynamic balance (r= -0.192, $P$=0.120).

The results showed that there were generally significant negative correlations ranged from small to moderate level between the measurements of strength and the balance performance from non-dominant leg of football players at all angular velocities (Table 4). These correlations were found between $ND_{EXT}60^0$/s and $DOE_{Cop-X}$, $DOE_{Cop-Y}$, $DCE_{CoP-Y}$, $BOE_{CoP-Y}$, $BCE_{CoP-Y}$, $NDOE_{CoP-X}$, $NDCE_{CoP-X}$, $NDCE_{CoP-Y}$; between $ND_{FLX}60^0$/s and $DOE_{CoP-X}$, $DOE_{CoP-Y}$, $NDCE_{CoP-X}$, $NDCE_{CoP-Y}$; between $ND_{EXT}180^0$/s and $DOE_{CoP-X}$, $DOE_{CoP-Y}$, $DCE_{CoP-Y}$, $BCE_{CoP-X}$, $NDOE_{CoP-X}$, $NDCE_{CoP-X}$, $NDCE_{CoP-Y}$; between $ND_{FLX}180^0$/s and $DOE_{CoP-X}$, $DOE_{CoP-Y}$, $DCE_{CoP-Y}$, $NDOE_{CoP-Y}$, $NDCE_{CoP-X}$, $NDCE_{CoP-Y}$; between $ND_{EXT}240^0$/s ile $DOE_{CoP-X}$, $DOE_{CoP-Y}$, $DCE_{CoP-X}$, $NDOE_{CoP-X}$, $NDCE_{CoP-X}$ and between $ND_{FLX}240_0$/s and only $DOE_{CoP-X}$ parameter (Table 4).

However, no significant relationships were generally determined between the measurements of peak isokinetic knee extension-flexion strength from non-dominant leg at three angular velocities: 60, 180 and 240$^0$/s and examined static balance in the bipedal position. Also, no significant relationship was observed between the measurements of $D_{FLX}240^0$/s and dynamic balance (r= - 0.227, $P$=0.067).

**Table 3: The relationship between knee extension and flexion muscle strength (Nm) at 60°/s, 180°/s, 240°/s angular velocities and balance performance in terms of dominant leg preference**

| *Parameters* | | *Kendall's tau-b* | $D_{EXT}$ $60^0$/s | $D_{FLX}$ $60^0$/s | $D_{EXT}$ $180^0$/s | $D_{FLX}$ $180^0$/s | $D_{EXTN}$ $240^0$/s | $D_{FLX}$ $240^0$/s |
|---|---|---|---|---|---|---|---|---|
| *Static* | $DOE_{CoP\text{-}X}$ | r- values | -0.636 | -0.489 | -0.531 | -0.385 | -0.484 | -0.318 |
| *Balance* | | *P*-values | **<0.001** | **<0.001** | **<0.001** | **0.005** | **<0.001** | **0.021** |
| | $DOE_{CoP\text{-}Y}$ | r- values | -0.581 | -0.480 | -0.472 | -0.442 | -0.244 | -0.222 |
| | | *P*-values | **<0.001** | **<0.001** | **<0.001** | **0.001** | 0.067 | 0.098 |
| | $DCE_{CoP\text{-}X}$ | r- values | -0.238 | -0.292 | -0.314 | -0.240 | -0.448 | -0.178 |
| | | *P*-values | 0.084 | **0.034** | **0.022** | 0.081 | **0.001** | 0.198 |
| | $DCE_{CoP\text{-}Y}$ | r- values | -0.418 | -0.272 | -0.309 | -0.293 | -0.171 | -0.078 |
| | | *P*-values | **0.002** | **0.044** | **0.022** | **0.031** | 0.207 | 0.566 |
| | $BOE_{CoP\text{-}X}$ | r- values | -0.274 | -0.045 | -0.241 | -0.047 | -0.146 | -0.092 |
| | | *P*-values | **0.049** | 0.749 | 0.083 | 0.736 | 0.296 | 0.510 |
| | $BOE_{CoP\text{-}Y}$ | r- values | -0.348 | -0.207 | -0.156 | -0.179 | -0.080 | -0.022 |
| | | *P*-values | **0.010** | 0.126 | 0.248 | 0.187 | 0.558 | 0.871 |
| | $BCE_{CoP\text{-}X}$ | r- values | -0.291 | -0.075 | -0.230 | -0.038 | -0.036 | 0.103 |
| | | *P*-values | **0.033** | 0.585 | 0.091 | 0.778 | 0.791 | 0.455 |
| | $BCE_{CoP\text{-}Y}$ | r- values | -0.348 | -0.255 | -0.175 | -0.160 | -0.187 | -0.067 |
| | | *P*-values | **0.010** | 0.060 | 0.197 | 0.240 | 0.170 | 0.624 |
| | $NDOE_{CoP\text{-}X}$ | r- values | -0.546 | -0.407 | -0.449 | -0.346 | -0.389 | -0.264 |
| | | *P*-values | **<0.001** | **0.003** | **0.001** | **0.010** | **0.004** | 0.052 |
| | $NDOE_{CoP\text{-}Y}$ | r- values | -0.215 | -0.287 | -0.181 | -0.283 | -0.113 | -0.219 |
| | | *P*-values | 0.115 | **0.035** | 0.185 | **0.038** | 0.407 | 0.111 |
| | $NDCE_{CoP\text{-}X}$ | r- values | -0.457 | -0.432 | -0.468 | -0.452 | -0.338 | -0.231 |
| | | *P*-values | **0.001** | **0.001** | **<0.001** | **0.001** | **0.012** | 0.088 |
| | $NDCE_{CoP\text{-}Y}$ | r- values | -0.281 | -0.206 | -0.360 | -0.323 | -0.368 | -0.219 |
| | | *P*-values | **0.039** | 0.130 | **0.008** | **0.017** | **0.007** | 0.110 |
| *Dynamic* | r- values | -0.676 | -0.484 | -0.445 | -0.269 | -0.321 | -0.192 | |
| *Balance* | *P*-values | **<0.001** | **<0.001** | **<0.001** | **0.029** | **0.009** | 0.120 | |

**Table 4: The relationship between extension and flexion muscle strength (Nm) at 60°/s, 180°/s, 240°/s angular velocities and balance performance in terms of non-dominant leg preference**

| *Parameters* | | *Kendall's tau-b* | $D_{EXT}$ $60^0$/s | $D_{FLX}$ $60^0$/s | $D_{EXT}$ $180^0$/s | $D_{FLX}$ $180^0$/s | $D_{EXTN}$ $240^0$/s | $D_{FLX}$ $240^0$/s |
|---|---|---|---|---|---|---|---|---|
| *Static* | $DOE_{CoP\text{-}X}$ | r- values | -0.369 | -0.422 | -0.466 | -0.338 | -0.478 | -0.319 |
| *Balance* | | *P*-values | **0.007** | **0.002** | **0.001** | **0.014** | **<0.001** | **0.020** |
| | $DOE_{CoP\text{-}Y}$ | r- values | -0.401 | -0.385 | -0.489 | -0.446 | -0.273 | -0.191 |
| | | *P*-values | **0.003** | **0.004** | **<0.001** | **0.001** | **0.040** | 0.153 |
| | $DCE_{CoP\text{-}X}$ | r- values | -0.218 | -0.217 | -0.246 | -0.145 | -0.319 | -0.103 |
| | | *P*-values | 0.114 | 0.114 | 0.073 | 0.292 | **0.020** | 0.458 |
| | $DCE_{CoP\text{-}Y}$ | r- values | -0.281 | -0.199 | -0.336 | -0.266 | -0.210 | -0.022 |
| | | *P*-values | **0.038** | 0.141 | **0.013** | **0.049** | 0.120 | 0.870 |
| | $BOE_{CoP\text{-}X}$ | r- values | -0.134 | -0.019 | -0.209 | -0.070 | -0.103 | -0.009 |
| | | *P*-values | 0.337 | 0.893 | 0.134 | 0.613 | 0.459 | 0.946 |
| | $BOE_{CoP\text{-}Y}$ | r- values | -0.298 | -0.156 | -0.185 | -0.207 | -0.048 | 0.067 |
| | | *P*-values | **0.028** | 0.248 | 0.172 | 0.126 | 0.720 | 0.625 |
| | $BCE_{CoP\text{-}X}$ | r- values | -0.238 | -0.002 | -0.273 | -0.061 | -0.027 | 0.173 |
| | | *P*-values | 0.082 | 0.987 | **0.045** | 0.655 | 0.842 | 0.207 |
| | $BCE_{CoP\text{-}Y}$ | r- values | -0.315 | -0.170 | -0.266 | -0.231 | -0.093 | -0.002 |
| | | *P*-values | **0.020** | 0.209 | 0.050 | 0.090 | 0.493 | 0.987 |
| | $NDOE_{CoP\text{-}X}$ | r- values | -0.318 | -0.249 | -0.391 | -0.246 | -0.385 | -0.186 |
| | | *P*-values | **0.018** | 0.063 | **0.004** | 0.068 | **0.004** | 0.170 |
| | $NDOE_{CoP\text{-}Y}$ | r- values | -0.102 | -0.253 | -0.165 | -0.294 | -0.020 | -0.134 |
| | | *P*-values | 0.456 | 0.064 | 0.226 | **0.031** | 0.881 | 0.328 |
| | $NDCE_{CoP\text{-}X}$ | r- values | -0.337 | -0.366 | -0.532 | -0.391 | -0.421 | -0.237 |
| | | *P*-values | **0.012** | **0.006** | **<0.001** | **0.004** | **0.002** | 0.079 |
| | $NDCE_{CoP\text{-}Y}$ | r- values | -0.330 | -0.329 | -0.278 | -0.350 | -0.234 | -0.243 |
| | | *P*-values | **0.015** | **0.015** | **0.040** | **0.010** | 0.084 | 0.075 |
| *Dynamic* | | r- values | -0.463 | -0.355 | -0.445 | -0.322 | -0.320 | -0.227 |
| *Balance* | | *P*-values | **<0.001** | **0.004** | **<0.001** | **0.009** | **0.009** | 0.067 |

## DISCUSSION

Strength and balance represent ground stones for daily functional movements for athletes' performance. Professional football training should aim to improve the extension-flexion muscles strength and balance performance of both dominant and non-dominant legs for high performance in football. Although this study was primarily designed to examine relationships between knee flexor-extensor muscular strength with respect to three different approach angles (60, 180 and 240$^0$/s) and balance performance of football players and establish norms for future studies in football players, certain additional information concerning the training and rehabilitation programs should be noted.

In this study, it was determined that static balance measurements taken from the football players with open eyes were smaller than the same measurements taken from football players with eyes closed (Table 1). It was further observed that isokinetic extensor and flexor muscles strength, measured from both the dominant and non-dominant leg, decreases as the rate of angular velocity increases (Table 2). It was reported that the mean values of isokinetic extension and flexion muscles strength at 60$^0$/s angular velocity for the Greek professional football players were a) 228.3 Nm and 126.5 Nm for dominant leg, b) 228.2 Nm and 126.7 Nm for non-dominant leg, respectively (Zakas 2006); for the Malaysian young professional football players a) 201.8 Nm and 101.1 Nm for dominant leg, b) 209.3 Nm and 102.3 Nm for non-dominant leg, respectively (Daneshjoo et al. 2013); the same measures at 180$^0$/s angular velocity for the Greek elite football players were 126 Nm and 93 Nm respectively (Poulmedis, 1985), for the Greek professional football players a) 163.1 Nm and 89.5 Nm for dominant leg, b) 162.2 Nm and 86.7 Nm for non-dominant leg, respectively (Zakas 2006); the same measures at 240$^0$/s angular velocity for the American football players were 105.40 Nm and 82 Nm respectively (Noguchi et al. 2012). These were measured as higher than the same conditions as those used in this study (180 and 240$^0$/s). Strength of knee flexors and extensors is an important factor for both football player's performance and injury prevention (Hrysomallis 2007). The low level of the value measured from our study may be due to a lack of match experience and training. So, it can be said that amateur football players reduce the chance to play in the professional league in terms of football player's performance and injury risk.

Static balance performance measurements taken from the non-dominant leg of amateur football players seemed higher than the same measurements taken from the dominant leg, while peak torques in the dominant leg at all angular velocities seemed higher than the non-dominant leg. To the researcher's knowledge, the relationship between the measurements of isokinetic knee extension-flexion strength from dominant-non-dominant legs of football players at different angular velocities and their balance performance is not fully explained. Results from previous studies investigating the relationship between strength, power and dynamic balance are conflicting (Thorbe et al. 2008; Erkmen et al. 2010; Hesari et al. 2013; Lockie et al. 2013; Muehlbauer et al. 2013a). The results confirm that there were generally a small to moderate negative correlations between the knee extensor-flexor muscular strength measured from both dominant and non-dominant sides of amateur football players at three angular velocities: 60, 180 and 240$^0$/s and their balance performance (Tables 3 and 4). The data showing the relationship between muscle strength and balance performance is very important in preparing the training programs to increase individual's performance in football. In the study, for isokinetic extension-flexion muscles strength and static balance performance from dominant legs of the football players, the highest correlations were between $D_{Ext}60^0$/s and $DOE_{CoP-X}$ (r= -0.636), $D_{FLX}60^0$/s and $DOE_{CoP-X}$ (r=-0.489); for isokinetic extension-flexion muscles strength and dynamic balance performance from dominant legs of the football players, the highest correlations were between $D_{EXT}60^0$/s and dynamic balance (r= -0.676), $D_{FLX}60$ and dynamic balance (r=-0.484) (Table 3); for non-dominant legs of the players, the highest correlations were between $ND_{EXT}180^0$/s and $DOE_{CoP-Y}$ (r=-0.489), $ND_{FLX}180^0$/s and $DOE_{CoP-Y}$ (r=-0.446); for isokinetic extension-flexion muscles strength and dynamic balance performance from same legs of the players, the highest correlations were between $ND_{EXT}60^0$/s and dynamic balance (r=-0.463), $ND_{FLX}60^0$/s and dynamic balance (r=-0.355) (Table 4). Nejc et al. (2013) reported that "If only strength and balance are somehow different in their underlying mechanisms, several studies have shown that they do correlate at a small to medium level (Pizzigalli et al. 2011; Pua et al. 2011; Brech et al. 2013). On the contrary, other studies have shown absence of correlation between strength and balance proposing the role of complementary diagnostics and training in their regard (Muehlbauer et al. 2012; Muehlbauer et al. 2013a; Muehlbauer et al. 2013b)". The results are supportive of the above presented strength-balance relationship (Tables 3 and 4). Cankaya et al. (2015) reported that the specific balance training improves balance performance of individuals, while these balance exercises reduce the risk of injuries of athletes. Heitkamp et al. (2001) stated that six week balance training increases the maximum voluntary isometric contraction force of the knee extensors and flexors of recreationally active subjects. Therefore, both the balance performance and isokinetic knee extension-flexion strength of amateur football players can be improved by special training.

## CONCLUSION

Studies on balance scores have generally been researched in sports branches other than football in the form of the effect of movements of specific times on balance scores; however, the associations between factors such as strength which affect sportive performance directly and balance scores have not been extensively studied. In this study which examined the relationship between balance and knee flexion and extension strength, it was found that extension and flexion muscle strength affected balance scores in low and mild levels and this effect was seen in both legs and dominant leg preference at most. Within this context, it can be said that the relationship between the isokinetic muscle strength (flexion and extension) applied at the lowest angle and balance scores was relatively higher. In other words, in low angles where strength can be applied ($60^0$/s and $180^0$/s) balance scores have better levels.

## RECOMMENDATIONS

According to the researcher's observations on football training, differences in strength profiles between the two legs may be considered as an important predictor of balance performance in football players. Therefore, 4-6 weeks pre-season strength training twice a week can be suggested to increase isokinetic knee extensors and flexors muscle strength values at different angular velocities in addition to the normal football training throughout the season. In this way, competition in the football players' individual performance can be increased. In further studies, examining the development of the participants' balance scores and isokinetic strength measured as pretest and posttest can help to define muscle-strength relationship better.

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