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Sprint, Jump Performances, and Force-Velocity Profile in A Well-Trained Football Player: A Pilot Study

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Abstract: The objective of this pilot study is to find the well-trained football players' force-velocity profile based on their sprint and jump performances. The participants of the study were boys (n=28), aged 19-21. To achieve the tasks, participants will be recruited to perform vertical squat jump tests against multiple external loads (vertical) by using the My jump 2 application and linear 30m sprints (horizontal) by using the My Sprint application to evaluate lower and upper limbs' force-velocity profiles of the players. The vertical and horizontal force-velocity profiling (i.e., theoretical maximal values of force (Fo), the maximal value of velocity (Vo), and maximal power (Pmax) as well as the main performances variable (unloaded Squat Jump height in jumping and 30m- sprint time will be measured. The slopes of those profiles will be calculated. If the player's Force-velocity profile (0-90%), players are force deficient. Strength-orientated training should be enforced on the player. If the player's Force-velocity profile (>120%), players are velocity deficient. Speed training should be focused on the player. This study is to identify which players are force deficit and velocity deficit. This pilot study provided a descriptive reference for the player to have more individualized training programs and thus increase the player's sprint and jump performances

Keywords: *Jump performance, Sprint performance, Force-velocity profile, Football Player*

1. Introduction

A well-trained football player must overcome all technical, tactical, physical, physiological, and psychological challenges[1]. Power is a vital necessity that can influence the outcome of football matches, especially when the players are sprinting, jumping, kicking, or changing direction[2]. Players who can perform well always provide more power in the shortest amount of time[3].

According to the International System of Units (SI), the unit for Power is watt (W) another simplest form of Power is Force multiplied by Velocity. Although power is not a measure of sporting ability, it has been considered to be a characteristic of athletic performance. Previous studies have discovered that the horizontal sprint (45%) and vertical jump (16%) are the most frequent activity during soccer tournaments [1,4]. Since both attractions have become the most important requirements in most of the action, many researchers or coaches have focused on describing the training program to produce optimal results for the player.

Through sprinting and jumping, it will produce a maximal power output that are produced by both force and velocity production[5-6]. This data will then create a force-velocity profile (Fv-profile) of the athlete and will be important data for implementing specific training programs[7].

Force-velocity profile provides information on the individual characteristics. It also shows the player is deficient either in force or in velocity[3].

The force-velocity profile allows coaches to identify and focus on the athlete's weakness, as well as prescribe appropriate individual training to overcome the problem, resulting in improved performance[8].

Pass researcher [9-12] conducted a study on effective

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strength training at increasing maximal force capabilities had shown a positive result by using high load (< 70 %RM) to the high deficit player and also (<30 % RM) or no load [13-14] to the velocity deficit player to increase the performance. Then [3,6] had specifically divided force and velocity deficit into 5 category instead of three which are high force, low force, well balanced, low velocity and also high velocity.

Both force deficit will be focuses on strength which the training load for high force deficit will be (80-90% 1RM) while low force deficit is (<70-80% 1RM) (Jiménez-Reyes et al., 2019). Meanwhile for well-balanced categories will be focuses on (10-45% BW) [3,6] For the high and low velocity deficit, the players will be focusing in speed training which uses body weight or less than body weight for the training loads [3,6].

In conclusion, training program are determined by individual force-velocity profile. Therefore, this current study aims to identify the player force-velocity profile to provide a descriptive reference for the coaches and the researcher to tailor a suitable individualize training.

2. Materials and Methods

2.1. Design

This study used an analytic study design to evaluate the jump and the speed of the player. Twenty-eight (n=28) male soccer players took part in this study by using convenience sampling. With this sampling selection, an individual was chosen in this study because they are available, convenient, willing, and represent a characteristic that the researcher sought to study[15].

2.2. Participants

Twenty-eight well-trained soccer players from the Sibu District Football Club (SDFC) volunteered to participate in this research. Players were only chosen if they met the inclusion criteria which were; healthy and aged between 19 to 21 years old, had a minimum structured training experience of at least 2 years under the supervision of a qualified strength and conditioning coach, each player also free from any injury or training restriction and verified by the club physiotherapist. Football training sessions generally started with warm-up activities like running and specific warm-ups for the upper and lower extremities from low to moderate intensity. The study was approved by the Human Ethics Committee of the Sultan Idris Education University, Malaysia, and conformed to the Helsinki Declaration. All participants signed an informed consent form before the study and were they were aware that they could withdraw at any point without explaining.

2.3. Research instrument

Before participants conduct any test, the participant's body weight, height, leg length and height at 90 degrees will be measured and the data will be transferred into Microsoft Excel and analyzed. Participants' body weight will be recorded using Seca 874 Mobile flat scales (Hamburg, Germany) and height measurement will be measured by using Seca 217 Stable stadiometer (Hamburg, Germany).

Quantitative data for the force-velocity profile will be collected by using a vertical and a horizontal test. The vertical test will be measured by using the squat jump with My jump 2 application while horizontal test data will be collected by using a 30m sprint run on a synthetic outdoor track with the My Sprint application.

Data for both tests will be recorded by using iPhone 11 (Apple) running iOS 16.1.1 which has a built-in 24 fps, 25 fps, 30 fps, or 60 fps high-speed camera at a quality of 1080p. The true depth camera with 720p HD video recording at 30fps on iPhone 11 enables quick take video.

2.4. Test Procedures

The tests were conducted at the same time of the day starting from 8.00 a.m. to 10.00 a.m. Each participant was asked to undergo body measurement and perform loaded squat jumps (SJ) and a 30 meters of split time test to identify the different components of the vertical and horizontal force-velocity profiles respectively at maximal force (Fo), maximal velocity (Vo), maximal power (Pmax), force-velocity slope, force-velocity imbalance, ratio force peak, and decrease ratio force.

Force-velocity relationships of the lower limb neuromuscular system in the Squat Jump (SJ) are used to determine individual Force-velocity profiles. Each participant was asked to perform maximal vertical jump without loads and opposed to five to eight extra loads by the range of 0%-80% of the body weight [16-18]. This test will be performed by using the Myjump application.

Before each participants conducted the Squat Jump (SJ), subjects were informed to stand straight and still in the jumping area. The participants need to put their arms on the hips for jumping without load and on the bar for loaded jump. Make sure the participants arms are maintained for the entire action. Participant need to sustain the starting position with the angle of 90- degree of knee bending for 2 seconds and then jump as high as possible to create the maximal force.

Jump test was recorded by using Myjump2 application [19] installed on an iPhone 11 (Apple). Countermovement is forbidden. If needs were not met, participant are required to repeat the test. Each load was performed with two valid trials with 2 min of rest between trials and 4 to 5 min or rest between load.

By using Samozino's method, mean mechanical parameter will be calculated[18] based on Newton's second law of motion, F=ma. Mean force (F), velocity (V) and power (P) can be calculated during a vertical jump. Jump height are accessible with Myjump 2 application. To calculate the Force, velocity and power, researcher need to key in the input variable such as: body mass, jump height and push off distance. The latter measurements count by the jumping height of the center of mass during push-off. For example, measurement from the starting position to take off [17] and to landing position.

Force-velocity relationships were quantify using the best trials of each maximal jumps of the player's using different load and the least squares linear regressions. Force-velocity curves, and force-velocity profile, will then be computed from maximal force (Fo) and maximal velocity (Vo) according to[20].

Next, participants performed 3 maximal afford of 30-m sprint test with 5 minutes rest in between trials on a synthetic outdoor track. Wind speed, ambient temperature, and pressure were measured for air-friction force[21] with an anemometer. Participant started from a starting position with the right hand on the track. 3 trials were recorded by using an iPhone 11 with the access of MySprint application. 6 cones were placed at 5m,10m, 15m, 20m, 25m, and 30m to get the split time measurements. To ensure a clear visual of the run, the smart phone was placed approximately 15m far from the middle of the running track with the aid of an tripod which at the adjustment height of 1 m corresponding to the height of the players' center-of-mass[20].

With the usage of MySprint application, it can easily make an analysis with the multiple split time from a high-speed video by marking the time-stamp of all 6 different markers that cross by the participants. Fixed position of the iPhone 11 creates a better video parallax.

The participants were viewed by the iPhone camera when their hips cross the targeted distance which at (5m,10m,15m,20m and 30m). After all the disclosure, MySprint application will automatically calculate each split time and sprint mechanical output by using the equation created by[22].

3. Results

All data will be compared and shown as mean± standard deviation (SD). To evaluate the results, data will be analyzed using the magnitude-based inference approach. If the values were normally distributed, Shapiro Wilk test will be used. SPSS software version 22.0 (SPSS Inc., Chicago, IL, USA) with the alpha level of 0.05 will be used for the statistical analysis.

Using the simple method based on five loaded squad jump and sprint tests, we determined Pmax and the imbalance (FVimb); the % difference between a player's actual and optimal Fv profile[21] and derived an initial result. 13 subjects fall into Force-deficit category (FD), 9 subjects in Velocity-deficit category (VD) and 6 subjects in the Well balanced category (WB). All group test shows an average of FVimb toward maximal force and velocity capabilities. From the table shown, the mean standard score for maximal power is M= 1292.794 (SD =361.414). Besides that, we also had calculated the mean and standard deviation according to the players methodology quality such as Age (M=19.75, SD= 0.74), Height (M=168.25, SD= 3.10), Weight (M=59.96, SD=3.71), Leg length (M=108.28, SD=3.95), Height at 90° (M=80.36, SD=4.40) and Force-velocity profile (M=84.11, SD= 50.76). (Table 1) gives the general outlook of the methodology quality of the included studies. The outcome was used to represent the summary of the force-velocity profile of each player.

4. Discussions

To the author's understanding, this is the initial study to evaluate the force-velocity profile of the players. This pilot study provides a descriptive reference for young and professional football players for more individualized training based on their force-velocity profiles.

According to the mean of the result, the majority of the players are between the age range of 19 years old, with a height of 168cm and weight is 60kg. Players' physical parameters (height and body weight) determine the player's position- wings and central play[23]. Differences in position play may influence the performance of the anaerobic power parameter[23]. Despite this, morphological traits can play a important role in deciding the success of the athletes[24]. Therefore, by doing this research, football coach can use this result to a better understanding and interpretation of anthropometric characteristics in their gaming position. This knowledge could create a better understanding of the selection of the players in the future. Besides that, we also discovered that a mean score of (M=1292.79) showed the maximal power of the football players. As we can see although maximal power can be very high at the same time, but player's weakness can be different either in force deficit or velocity deficit.

Individualize training will tailor according to the player's weakness and will be based on Fv-spectrum that had been proposed by [6] as a guideline to increase the player's performance. Players who are in a force deficiency should aim to increase maximal power while decreasing FVimb by increasing the strength power in advance, (Fo)[25]. Earlier studies clearly show the efficiency of strength training aims at notably increasing maximal force proficiency [9-12]. They had shown a visible performance by using high load (<70% RM) through training. Due to no specify of the volume of training, many pass researcher [26-27] has used different loading but maintaining the same volume. This action had resulted a trivial performance due to volume has reached a minimum threshold[28]. According to[29], High intensity is perfectly matched with lower volume training to avoid injury and thus increase strength, stamina, and power training. Regarding the use of heavy load with low volume in resistance training, a study reported improvement in muscle gain in the upper part of the force-velocity curve[30].

Players who had velocity deficiency should focuses to maximal velocity capabilities example speed training with a minimum of null braking phase for example a throw at the end of a lift and a low load with (<30% RM) or no loads [14,31]. This low intensity is matched with a higher volume of training[32]. High-volume power training can enhance high-intensity efforts as well as improve physical qualities[33]. Furthermore, work out with the maximal movement velocities (e.g. >90% of maximal velocity) has shown to avoid metabolic fatigue. Future researcher should look into the effects of heavier or lighter volume of individualize training for the force-velocity profile.

5. Conclusions

We have observed that the majority of the players are more prone to force deficit which means that players are required to train toward strength training to improve their performance. However, there are some of the players that have optimal FV profiles and some even have an imbalance toward velocity deficits. Velocity deficits players are required to train toward the speed. This indicates that players are required to be individualized trained instead of group training which will affect the players' performances.

However, to ensure an effective performance, there are few limitations that needs to take into consideration. First, as discuss, fv-spectrum proposed by[3] did not clearly stated the difference in the volume taken during the intervention.

Second, future research needs to consider selecting a suitable participant when conducting in any research. Pass researcher [26] had used the elite participation in their intervention. It turns out that, jump height might shows small improvement due to low number of training sessions. Therefore, future researcher should avoid using higher level of players which will affect the attendance of the training and indirectly influence the performance.

Third, avoid using different measurement or device can affect the absolute values of the force-velocity profile. Pass researcher[26] used two different device such as iPhone vs force-plate. Consequently, [26] was unable to reduce or increase Fvimb of the training group.

Forth, future researcher should consider using longer training duration to reach optimal power production instead of using the fixed training duration. Pass researcher [6,26 27,34] had set up a fixed duration training which is 9 weeks or less on individualized training program, but did not shows drastic improvement compared to the dynamic individualized approach[3]. The larger the individual force-velocity deficiency, the longer the training period needed to reach an optimal profile. Therefore, future researcher needs to ensure the individualize training not only for the matters but also consider the training period[3].

Fv-imbalance could define as an excellent vade mecum for prescribing optimal resistance training to enhance ballistic performance[6]. According to[6], this force-velocity profile may help to boost up player's explosive push-off through an efficient monitoring chart. Therefore, this study is important as a first study to have an initial analysis to categorize players into different groups for further individualized training. In conclusion, although the present study can only be overview as a pilot study, it provides a point of departure for future studies.

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Table 1. Raw data of the players

Players	Age	Height	Weight	Leg length	Height at 90 degrees	Fv-Profile	Fv-Imbalance %	Maximal Power
Player 1	19	170	60	115	76	141	41 (VD)	848.190
Player 2	20	171	55	109	80	105	5 (WB)	1800.035
Player 3	19	167	57	106	76	50	50 (FD)	1377.018
Player 4	20	168	53	106	76	170	70 (VD)	1488.029
Player 5	21	168	60	112	76	95	5 (WB)	1700.894
Player 6	19	170	63	109	80	34	66 (FD)	1352.743
Player 7	20	169	62	107	78	49	51 (FD)	945.032
Player 8	20	168	58	105	78	168	68 (VD)	1291.616
Player 9	19	161	55	104	77	20	80 (FD)	974.026
Player 10	19	173	65	102	71	103	3 (WB)	1400.893
Player 11	19	168	63	109	78	76	24 (FD)	2170.927
Player 12	20	171	68	103	80	56	44 (FD)	1728.902
Player 13	21	170	64	104	86	108	8 (WB)	1500.673
Player 14	19	166	60	115	87	143	43 (VD)	1189.077
Player 15	20	166	62	107	82	134	34 (VD)	960.722
Player 16	19	161	57	103	89	90	10 (WB)	1200.034
Player 17	19	173	60	104	90	13	87 (FD)	905.581
Player 18	20	166	62	112	82	52	48 (FD)	834.064
Player 19	20	165	63	111	85	19	81 (FD)	887.392
Player 20	20	165	59	113	83	119	19 (VD)	2093.077
Player 21	20	167	55	106	77	23	77 (FD)	1200.023
Player 22	19	173	60	112	76	129	29 (VD)	1309.381
Player 23	21	169	53	115	79	20	80 (FD)	1082.261
Player 24	21	165	62	109	83	157	57 (VD)	1386.783
Player 25	21	170	60	106	86	21	79 (FD)	1110.128
Player 26	20	172	63	109	80	140	40 (VD)	922.926
Player 27	19	170	57	108	79	27	73 (FD)	937.151
Player 28	19	169	63	111	80	93	7 (WB)	1600.657
Mean $\bar{x}$ Standard deviation σ	**$\bar{x}$= 19.75 σ=0.74**	**$\bar{x}$= 168.25 σ=3.10**	**$\bar{x}$= 59.96 σ=3.71**	**$\bar{x}$= 108.28 σ=3.95**	**$\bar{x}$= 80.36 σ=4.40**	**$\bar{x}$=84.11 σ= 50.76**		**$\bar{x}$ =1292.79 σ = 361.41**

Abbreviation: Fv, Force-velocity; FD, Force Deficit; VD, Velocity Deficit; WB, Well-balance