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Original article

Power and endurance in Hong Kong professional football players

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Abstract

Background: The purpose of this study was to investigate the power and endurance characteristics of Hong Kong professional football players. Training recommendations can be deduced based on the comparison between Hong Kong and international football players.
Methods: Eighty-eight Hong Kong professional football players (height, 177.2 ± 6.4 cm; weight, 70.6 ± 7.6 kg; age, 25.6 ± 5.0 years) in the first division league participated in a battery of tests, which included: (1) height, (2) weight, (3) countermovement jump, (4) 30-m sprinting, and (5) Yo-Yo Intermittent Recovery Test Level 2.
Results: Compared with the test results of the first division players in other countries as reported in the literature (Norway, France, and Scandinavian countries), Hong Kong players were shorter in height (0.1–2.1%), lighter in weight (5.5–8.3%), fair in vertical jump height (−4.8–17%), slower in acceleration (4.2–5.1%) and maximum speed (3–14.2%), and had poorer aerobic and anaerobic endurance (22.9%).
Conclusion: The present study suggests that Hong Kong football players (or players with similar physique and ability) need to improve their power and endurance.

Keywords: endurance; field test; fitness; football; power

Introduction

Football is the most popular sport in the world with 260 million football players in the world.[1] Football performance is composed of technical, tactical, physiological, and mental areas.[2] Physical fitness is one of the most important elements that affect football team performance because of the high physical demand in the real match situations.[2,3] Football players have to perform many activities with explosive power. A sprint bout occurs every 90 seconds which lasts for 2–4 seconds. It constitutes 1–11% of the running distance covered in a football match.[2] Players also have to perform 150–250 intense movements in a match, such as tackles, heading, cutting, and sprinting.[2] Furthermore, forceful muscle contractions to maintain body balance and control of the ball against defensive pressure (i.e., body contact situation) is also a situation that commonly occurs during a football match.[2] In the endurance context, each player has to complete a distance of 8–12 km in a match, and the average work intensity is between 80% and 90% of the maximal heart rate.[2] Hence, power and endurance are the key fitness elements for players to perform well for the aforementioned activities in a football match.

Football players at the professional level usually have better physical abilities compared with semiprofessional or amateur players, probably because of the higher physical demand in a professional football match. Cometti et al[4] found that

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professional players differ from amateurs in terms of knee flexor muscle strength and short-distance sprinting speed. Top tier players were also found to have more high-speed run distance during a match than moderate-class players in the match analysis.[5] Previous studies have shown that players at a higher playing level had better aerobic and anaerobic performance in terms of Yo-Yo Intermittent Recovery Test performance.[5,6] These studies indicated that lower limb muscle strength and power, speed, and aerobic and anaerobic endurance are critical to distinguish the players' physical performance at different playing levels.

It is important for teams at lower playing levels to know their players' physical weaknesses compared with players at a higher playing level. Hence, suitable training focusing on particular weaknesses can be offered. The purpose of the current study was to determine the power and endurance characteristics of Hong Kong professional football players or players with similar physique for strength and conditioning specialists to design suitable training programs.

Materials and methods

Study design

Three fitness tests were done on Hong Kong professional football players: (1) countermovement jump (CMJ), (2) 30-m sprint, and (3) Yo-Yo Intermittent Recovery Test Level 2 (YYIR2). These tests represent the lower limb power, speed, and endurance of football players and were used in chosen previous studies.[4,7–9] Height and weight were measured to represent the demographic characteristics. The tests were done on an artificial turf at the end of the preseason period. A 24-hour to 48-hour rest period was offered to the participants prior to the test day. All procedures described in this study were approved by the Joint Chinese University of Hong Kong–New Territories East Cluster Clinical Research Ethical Review. Informed signed consent was provided by each participant before the study started.

Participants

Eighty-eight Hong Kong professional football players participated in a battery of fitness test (height, 177.2 ± 6.4 cm; weight, 70.6 ± 7.6 kg; age, 25.6 ± 5.0 years). Only individuals aged 18–35 years who played in the first division football league in Hong Kong were included. This was the highest level league in Hong Kong, and it has been renamed as Hong Kong Premier League since the 2014 season. Individuals were excluded if they had any injury or disease affecting their physical performance on the test day. These participants were trained at 5–7 sessions/wk during the preseason period (4–6 field sessions and 1–3 weight training session in the gym). Each field training session consisted of 10 minutes of warm up, 30 minutes technical and tactical training, 30 minutes simulated competition, 30 minutes fitness training, and 10 minutes of cool down. Each weight training session was about 90 minutes in length, and included upper limb, lower limb, and core exercises.

Procedure

All measurements of participants were taken on the same day in the following sequence: height, weight, CMJ, 30-m sprint, and YYIR2. Each participant performed warm-up exercises for 15 minutes, including slow jogging, dynamic stretch, and static stretch, prior to all the tests.

CMJ. An electronic jump mat (Smartjump; Fusion Sport, Queensland, Australia) was used to measure the maximum height of the CMJ. The participants were instructed to squat down quickly and jump up immediately and explosively with arm swing. No prior step was made prior to the jump. Three trials were conducted, and the best trial was used for analysis. Each trial was separated by at least 5 minutes of rest to enhance full recovery. Using a jump mat to test CMJ was proven to have a high test–retest reliability ($r = 0.99$).[10] Peak power was calculated from the CMJ result using the following formula: 60.7 × [jump height (cm)] + 45.3 × [body mass (kg)] − 2055.[11]

30-m sprint. The participants were instructed to sprint through a 30-m distance with their maximum effort. Time was recorded using an infrared speed gate (Smartspeed; Fusion Sport) placed at the start, as well as a 10-m, 20-m, and 30-m location. Each trial was separated by a 10-minute rest to enhance full recovery. High reliability was reported in previous studies for 10-m, 20-m, and 30-m sprint (intraclass correlation coefficient > 0.91).[12,13]

YYIR2. YYIR2 determines an individual's ability to recover from repeated exercise with a high contribution from both aerobic and anaerobic systems.[7] Thus, this test represents both the aerobic and anaerobic energy systems turnover during intense exercise.[7,8] The protocol is an incremental shuttle run interspersed with active recovery. The test consists of many bouts of 2 × 20 m shuttle runs at increasing speeds, interspersed with a 10-second period to cover 2 × 5-m distance. Participants were verbally instructed prior to the familiarisation. Three bouts of familiarisation were given to these players. A 10-minute rest was given before the test started. The test was terminated when the participant was unable to maintain the required running speed. The total running distance covered in the test reflects the endurance performance. The test–retest coefficient of variance for the YYIR2 test has been reported as 9.6%.[14]

Statistical analysis

Data were analyzed using SPSS version 16.0 for Windows (SPSS Inc., Chicago, IL, USA). The data were presented as mean and standard deviation. The mean difference of each variable between Hong Kong players and international players from previous studies is presented as a percentage.

For the CMJ performance, adjustment was made on the data from the study of Cometti et al[4] owing to the difference in jumping technique. Akimbo position (arm on waist) was used by French players,[4] whereas arm swing was allowed for

Hong Kong players. Arm swing was found to contribute 10% to an individual's performance in a vertical jump in terms of jump height.[15] Thus, the CMJ data of the study of Cometti et al[4] was adjusted with a 10% increase prior to the data comparison.

Results

The physiological data of Hong Kong professional players and comparable data from previous studies[4,8,9] are shown in Table 1 (demographic), Table 2 (CMJ height and sprint time), and Table 3 (YYIR2 distance).

Hong Kong players were shorter in height (0.1−2.1%) and lighter in weight (5.5−8.3%) than the Norwegian, French, and Scandinavian players in three previous articles.[4,8,9] The body mass index of Hong Kong players was 2.7−18.3% less than those players.

Hong Kong players jumped lower than Norwegian players (17%) but jumped higher than French players (−4.8%).[4,9] Hong Kong football players were found to have slower acceleration and maximum speed during sprinting. The 10-m sprint time and the 10−30-m sprint time of Hong Kong football players were found to be 4.2−5.1% and 3−14.2% slower than those of the Norwegian and French players, respectively. Hong Kong football players had poorer YYIR2 distance than the Scandinavian players (840.5 m vs. 1033 m).

Table 1
Comparison of demographic details between professional soccer players from different countries.

	Hong Kong	Norway[9]	France[4]	Scandinavian countries[7]
	Mean (SD)	Mean (PD)		
Age (y)	25.6 (5.0)	25.8	26.1	23.0
Height (cm)	177.2 (6.4)	177.3 (0.1)	179.8 (1.5)	181.0 (2.1)
Body weight (kg)	70.6 (7.6)	76.5 (8.3)	74.5 (5.5)	74.9 (6)
BMI	22.5 (1.7)	24.4 (8.7)	23.05 (2.7)	22.86 (18.3)

BMI = body mass index; PD = percentage difference of mean value compared with Hong Kong players; SD = standard deviation.

Table 2
Comparison of CMJ variables and sprint time between professional soccer players from different countries.

	Hong Kong	Norway[9]	France[4]
	Mean (SD)	Mean (PD)	
CMJ (cm)	48.0 (5.4)	56.4 (17)	45.7 (−4.8)[a]
Power (W)	4066.6 (418.8)	4833.9 (13.6)	4085.3 (0.5)[b]
10-m sprint time (s)	1.90 (0.1)	1.82 (4.2)	1.804 (5.1)
20-m sprint time (s)	3.17 (0.13)	3.0 (5.3)	—
30-m sprint time (s)	4.39 (0.18)	4.0 (8.8)	4.22 (3.8)
10−20-m sprint time (s)	1.28 (0.1)	1.18 (7.8)	—
20−30-m sprint time (s)	1.21 (0.1)	1.0 (17.4)	—
10−30-m sprint time (s)	2.49 (0.1)	2.18 (14.2)	2.416 (3)

CMJ = countermovement jump; PD = percentage difference of mean value compared with Hong Kong players; SD = standard deviation.
[a] The CMJ height of French players was 41.56 cm using akimbo position; the current result was adjusted to estimate the result of CMJ with arm swing.
[b] The power of French players was calculated using adjusted CMJ height.

Table 3
Comparison of YYIR2 distance between professional soccer players from different countries.

	Hong Kong	Scandinavian countries[7]
	Mean (SD)	Mean (PD)
YYIR2 distance (m)	840.5 (263.0)	1033 (22.9)

PD = percentage difference of mean value compared with Hong Kong players; SD = standard deviation; YYIR2 = Yo-Yo Intermittent Recovery Test Level 2.

Discussion

Demographic comparison

Hong Kong players are shorter in height and lighter in weight than European players in previous reports.[4,8,9] The body mass index of Hong Kong players was 2.7−18.3% less than that of European players. Assuming the players had similar body fat percentages,[16,17] Hong Kong players had lower body musculature than their European counterparts. The average age of Norwegian (25.8 years) and French (26.1 years) players was similar to that of our study participants (25.6 years), whereas Scandinavian (23.0 years) players were 2.4 years younger than our participants, which may be a contributing factor to the difference in endurance performance. However, Toth et al[18] showed that peak oxygen consumption declined with age. According to the formula in the Toth et al[18] study, a 0.034-L/min decrease in peak oxygen consumption was found for each year of age decline. Therefore, the difference in age between Hong Kong players and Scandinavian players should not substantially affect the comparison of endurance performance.

CMJ comparison

Compared with two previous studies that investigated the relationship between jumping and sprinting abilities of professional football players in France and Norway, Hong Kong football players have poorer lower limb power than the players in both countries. Hong Kong players jumped lower than Norwegian players (17%), but jumped higher than French players (−4.8%, adjusted data).[4,9] However, because the Norwegian and French players were 5.5−8.3% heavier than the Hong Kong players, the lower limb power of Hong Kong players was the lowest among the three groups. Meanwhile, CMJ data can also estimate the highest height reached for heading in conjunction with the body height data. The result implied that Hong Kong players may have a disadvantage in terms of the highest height reached for heading a ball compared with Norwegian and French players (225.2 cm vs. 233.7 cm vs, 225.5 cm).

Speed comparison

Compared with the studies discussed above, Hong Kong football players were found to have slower acceleration and maximum speed during sprinting. The 10-m sprint time and the 10−30-m sprint time of Hong Kong football players were found to be 4.2−5.1% and 3−14.2% slower than those of the Norwegian and French players, respectively. The difference in the lower limb muscle power is believed to be attributable to the difference in sprint performance. Vescovi and McGuigan[19] showed that CMJ results were significantly correlated with 9.1-m, 18.3-m, and 27.4-m sprint time ($r < -0.658$) in collegiate football players. This explains why Hong Kong players had both lower vertical jump and sprint performance than the Norwegian and French players. Strength in terms of one repetition maximum squat weight was found to be highly correlated to CMJ and sprint performance.[9] These lines of evidence implied that poor muscle strength may be one of the leading causes of poorer lower limb power and sprint performance seen in Hong Kong football players. Therefore, training that focus on lower limb muscle strength should be adopted to tackle this weakness.

Lower limb muscle strength estimation according to jumping and sprinting performance

Our results implied that Hong Kong football players may have less lower limb strength compared with Norwegian and French players. Overall, 10-m sprint performance, 30-m sprint performance, and CMJ performance have been proven to correlate with maximal squat strength in elite football players.[9] Hong Kong players have poorer 10-m sprint performance, 30-m sprint performance, and CMJ performance compared with Norwegian and French players, which implied that Hong Kong players had poorer lower limb muscle strength.

To tackle the predicted weaknesses in the jumping, sprinting, and body contact situation, maximal strength training (i.e., training intensity between 4 and 6 repetition maximum[20]) is recommended for Hong Kong football players.[21] Maximal strength training improves neural adaptation, which increases the muscle fibre recruitment. Therefore, both absolute strength and relative strength (strength relative to body mass) can be improved while minimal muscle mass is gained.[21] Increase in absolute strength enabled Hong Kong players to produce more force during body contact situations.[22] The increase in relative strength enabled Hong Kong players to run faster to the space during the match, which may reduce the occurrence of body contact situations.

Endurance comparison

Hong Kong players had poorer aerobic and anaerobic endurance compared with Scandinavian players, as represented by their YYIR2 performance (840.5 m vs. 1033 m). YYIR2 performance was correlated to the VO_{2max} and the peak high intensity running distance in 5 minutes during a match.[7] Therefore, the result reflected that Hong Kong players had poorer endurance to sustain intermittent performance in the latter part of a football match (i.e., aerobic performance), and the ability to sustain high-intensity movements within a short time span (i.e., anaerobic performance). Endurance performance is gaining more importance in football matches nowadays. The defence player's density is increased during a football match,[23] i.e., defence players run more rapidly and frequently to block their opponents and recover the ball to develop a quick and organised counterattack. By contrast, more players in an offence are needed to offer more options for attack to put the opposition's defence under greater pressure.[24] As such, the high requirement of the aerobic and anaerobic performance of players is essential to compete in high-level football games nowadays.

Taking all the test results into consideration, two comments can be made. (1) Aerial attack strategy should be less advantageous for Hong Kong football players because of their shorter body height and lower CMJ height. (2) Body contact situations should also be avoided to decrease the chances of losing ball possession. Therefore, ground attack, rapid movement to the space, and short passing may be more suitable for Hong Kong football players to overcome those fitness weaknesses.

To fulfil the suggested team tactic, a more intense run (to space) is needed from each player to create passing opportunities. This raises the demand for both the aerobic and anaerobic energy systems of players to sustain their high-intensity efforts during the match. As such, high-intensity interval training (HIIT) may be a suitable method for Hong Kong football players to improve their aerobic and anaerobic performance. HIIT was proven to provide both central (aerobic and cardiovascular) and peripheral (anaerobic) improvement.[25,26] Twenty sessions of HIIT run (2 sets × 12−15 bouts of 15 seconds run at the players' 120% maximal aerobic speed) improved the endurance capacity and speed, in terms of maximal aerobic speed and 40-m sprinting performance of professional players by 8.1% and 3.5%, respectively.[26] By contrast, less training volume can be used to induce a similar training effect. Faude et al[25] noted that about 70% of HIIT can induce a similar training effect as a continuous run in terms of training time. With the suggested training method, Hong Kong players should be able to sustain more high-intensity runs throughout the match to carry out the “ground attack, rapid movement to the space, and short passing” tactic.

Conclusion

Hong Kong football players have poorer physique and physical abilities compared with European players, according to the literature, in terms of demographic characteristics, muscle power, jump height, speed, and endurance performance. Hong Kong football players or players with similar physique not only need to focus on tactical training but also need to improve their physical abilities to gain competitiveness at the international level. Ground attack style is recommended for Hong Kong football players because of their disadvantages in body height and jump height. To fulfill the playing style, Hong Kong players need to sustain more high intensity and rapid movement to the space during a football match, which can create more passing opportunities. Sufficient muscle strength is also necessary to gain ball possession in body contact situations. To achieve the suggested playing tactic, Hong Kong players are suggested to train with (1) maximal strength training to improve their muscle strength and power and (2) HIIT to improve both aerobic and anaerobic performance.

Conflicts of interest

The authors have no conflicts of interest relevant to this article.

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