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3x3 Basketball Competition: Physical and Physiological Characteristics of Elite Players

Paul G Montgomery* and Brendan D Maloney

Exercise and Sport Science, Aspetar Orthopaedic Hospital, Griffith University, Qatar

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***Corresponding author:** Paul G Montgomery, Exercise and Sport Science, Aspetar Orthopaedic Hospital, Griffith University, Qatar, Tel: 401345041 ; Email: paulmontgomery1@live.com.au

Abstract

Objective: To determine the physical and physiological characteristics of elite 3x3 basketball players.

Design: Observational research.

Methods: 123 males and 73 females competing in selected international tournaments were assessed with basic anthropometry (height, body mass) and standardized performance tests comprising explosive power (counter-movement jump), speed (20 meter sprint), repeat effort ability (suicide line-drill), high intensity endurance (YoYo intermittent recovery test level 1) and basketball specific agility. Differences in the means for all groups and performance tests were compared using Effect Size and percentage difference (ES; ±CL, %) of log-transformed data. Results: Anthropometrically, there is little difference between junior and senior male players, although junior females were smaller and lighter than senior players at the European level. 20-meter speed deteriorates for males, with players at professional levels slower than junior and senior levels. Moderate to large differences were observed in aerobic capacity for senior and junior males, and no difference between female levels.

Conclusion: This preliminary evaluation of 3x3 basketball suggests that elite players reflect some attributes of the "wing-perimeter player" in traditional basketball but are lacking in some physiological capacities. As this exciting sport develops and financial incentives to compete increase, it may be possible that players with speed and agility characteristics with fatigue resistance who are talented "shooters" will begin to dominate the game.

Keywords: Repeat-Effort; Speed; Performance; Testing; Ability

Introduction

Small sided games within basketball are not new to the training environment, with coaches often using restricted player scrimmage variants of 2x2, 3x3 and 4x4 in both the full and half-court to develop both tactical and fitness characteristics of their players. However, with 3x3 basketball making its first international appearance at the 2010 Singapore Youth Olympic Games, structured international competition of the 3x3 format is now common. Since this introduction there has been increasing popularity of 3x3 basketball internationally; According to an IOC-commissioned study, 3x3 is now the most popular urban team sport in the world1 and has received recent inclusion to the 2020 Olympic games. 3x3 Basketball resembles the regular characteristics of traditional basketball, in that the objective is to score more points than the opposition by shooting the ball through the hoop, with the dribbling and foul rules retained. However, 3x3 has many unique characteristics; the basic requirements are that the ball is of a smaller size, a regular 3x3 court playing surface is 15m (width) x 11m (length) with only one hoop, there are only 4 team members with 3 of these allowed on the court at any one time, and the 4th being substituted without limitation or official bench interaction during any dead-ball situation. Playing time is only 1 x 10 minute period, with a 12 second shot clock; a shot rebounded by the defensive team must be returned to outside the traditional 3-point line before transition to offence; shots made from beyond the traditional 3-point line are counted as two points; and if a team reaches 21 points within the 10 minutes they are deemed the winner2 [1-5].

The physiological and movement demands of a sport often determine the attributes and physical characteristics of the athletes who participate in that sport. The physical and physiological characteristics of traditional basketball players are well documented3-12 with specific innate characteristics such as height, mass, arm span and muscle mass orienting players to one of the traditionally designated playing roles of guard, forward and centre. Assessment of positional role differences in the aerobic and anaerobic power of elite male basketball players described that there was a clear difference between the different groups of players, with guards and forwards exhibiting greater aerobic

and relative values of anaerobic power, which would allow for shorter recovery times, and an ability to repeat high-intensity efforts13. Centres presented greater values of absolute anaerobic power and capacities, permitting greater force production during discrete tasks such as jumping13. The results of a recent study also demonstrated that a strong relationship exists between body composition, and physiological attributes of aerobic fitness, anaerobic power, and positional roles in elite traditional basketball14. However, within 3x3 basketball, specific positional roles are less apparent, and it is unclear if players who are now regularly competing in international 3x3 competition require, or comprise these same attributes, or if they differ to traditional basketball athletes in that they are specialists or players transitioning from the traditional game to the 3x3 format. For example, height may be less of an advantage in 3x3, with speed and agility in a confined playing space may be more important than aerobic capacity, therefore shorter 'perimeter' players may excel in 3x3 [5-10].

Earlier studies using cross-sectional mixed designs (i.e. age x competitive level) in team sports such as football were effective in showing fitness determinants of success, finding that there are major fitness differences by gender for a given competitive level in football players, and that gender rather than age differentiated players in speed, but not aerobic tests15, 16. Basketball has been reported as a high-intensity game that requires well-developed aerobic and anaerobic capacities to be successfully played10. The results of that study showed that to be successful as an elite player well-developed intermittent aerobic endurance is required (i.e. Yo-Yo IR1 performance). Furthermore, it was performance in this test that players showed the greater difference across age categories; specifically, senior players showed 48% and 24% higher capacity or ability (distance covered) than junior players at Under-18 and Under-20 level, respectively10. However, it is not known if these differences exist for junior and senior players who now compete in elite international 3x3 competitions. The objectives of this study were to describe the physical and physiological characteristics of elite 3x3 basketball players competing at diffing international levels.

Methods

Basketball players (Male; n=123, 24.4 ± 6.9yrs, 84.3 ± 15.7kg, 188.8 ± 10.9cm and female; n= 208, 22.4 ± 5.2 yrs, 67.7 ± 8.6kg, 177.2 ± 7.3cm) participating in the 2016 FIBA 3x3 under 18 World Championships, Senior European and World Championships, and selected professional International Basketball Federation (FIBA) World Tour events were asked to participate in the observational and descriptive analysis under individual federation agreements as defined by FIBA. After ethical approval, written and verbal explanation of the study provided by the FIBA Medical Commission, players providing consent and choosing to participate in the performance testing completed a series of basketball specific performance tests prior to competition periods, or on the day after their exclusion from a tournament. Briefly, these tests included a 20m sprint test, a basketball specific agility test, countermovement jump test, anaerobic repeat effort line-drill (suicide drill) and the YoYo intermittent recovery test (Level 1). These tests were used to describe the physical and physiological characteristics of 3x3 players and have been used extensively within traditional basketball as described previously17. Performance tests were administered by the authors to ensure consistency; all tests were completed indoors on a sprung wooden floor. Comparisons were made between the participating players from international tournaments, for both males and females, and where possible, to data reported in peer reviewed published literature that contained the same tests on players competing in elite traditional 5x5 basketball; this was collated, and the mean value for the available data used [10-28].

Statistics

Simple descriptive statistics are reported as mean ± standard deviation (mean ± SD). Differences in the means for all groups and performance tests were compared using log-transformed data as per methods outlined previously18. Magnitude-based inferences for the differences between groups were made by standardizing differences using the between-group standard deviation. Precision of estimates was indicated with 90% confidence limits (CL), which defines the range representing the uncertainty in the population mean. Effect Size and percentage difference (ES; ±CL, %) were characterized for the practical significance rather than simple interpretation of statistical significance19. Magnitudes of effect sizes were assessed and classified using the criteria of: <0.2; trivial, 0.2-0.6; small, 0.6-1.2; moderate, 1.2-2.0; large and >2.0; very large. Inferences about magnitudes were mechanistic: if the confidence interval overlapped thresholds for substantial positive and negative values (±0.20 standardized units), the effect was deemed unclear; effects were otherwise deemed clear20.

Results

Player characteristics and performance test results are provided in Table 1. Physical characteristics of height (Figure 1) and weight (Figure 2) revealed that males and females had similar characteristics for these attributes as forwards and guards respectively as described in literature, therefore we conducted all performance comparisons based on the similarity of these traditional positions.

Table 1: Physical and performance test characteristics of male and female 3x3 basketball players.

	Age (yrs)	Mass (kg)	Height (cm)	Vertical Jump (cm)	Agility L (s)	Agility R (s)	Line Drill (s)	20 m Speed (s)	Yo-Yo IRT L1 (level)	Yo-Yo IRT L1 (m)
Females										
3x3 WCh	25.7 ± 4.5	68.7 ± 9.2	178.1 ± 7.5	41.4 ± 8.6	6.45 ± 0.30	6.47 ± 0.33	31.09 ± 2.29[c]	3.56 ± 0.31[c]	15.6 ± 1.9	1033.3 ± 499.1

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3x3 ECh	27.5 ± 4.0	70.8 ± 9.6[c]	179.8 ± 6.9[c]	41.9 ± 9.4[c]	6.78 ± 0.25	6.61 ± 0.35	32.04 ± 0.95[c]	3.56 ± 0.20	15.4 ± 1.3	945.7 ± 356.9
3x3 u18	17.4 ± 0.9	67.4 ± 9.2[a, c]	176.5 ± 7.7[a, c]	40.5 ± 6.9	6.83 ± 0.33[b]	6.89 ± 0.40[a, b]	33.35 ± 4.29[c]	3.62 ± 0.19[c]	15.3 ± 1.0	898.8 ± 330.5
Literature		68.0 ± 3.2	173.1 ± 5.6	49.7 ± 3.2	5.80 ± 0.23	5.85 ± 0.25	30.20 ± 1.30	3.40 ± 0.01	16.4 ± 1.3	1240 ± 400.0
Males										
3x3 WCh	29.4 ± 5.4	95.2 ± 10.8	194.7 ± 7.4	60.4 ± 15.5	6.22 ± 0.48	6.01 ± 0.40	28.97 ± 1.33	3.19 ± 0.19[c]	18.0 ± 2.3	1751.6 ± 716.7[a, c]
3x3 ECh	29.3 ± 5.4	94.7 ± 11.4	195.4 ± 6.9	64.6 ± 11.0	6.20 ± 0.40	6.30 ± 0.30	28.80 ± 1.40	3.20 ± 0.20	16.4 ± 1.7	1257.1 ± 546.8[c]
3x3 u18	17.9 ± 0.5	85.5 ± 9.1[a, b]	193.4 ± 7.8[c]	56.4 ± 7.7[a]	6.09 ± 0.34	6.10 ± 0.43	28.96 ± 1.44	3.12 ± 0.15	16.8 ± 1.5	1381.3 ± 488.2[b, c]
3x3 Pro	31.0 ± 4.6	97.3 ± 11.5	194.4 ± 7.7[c]	59.7 ± 7.4	5.88 ± 0.41	5.96 ± 0.53	30.00 ± 1.81	3.35 ± 0.20[c]	16.0 ± 1.4	1120.0 ± 429.9[c]
Literature	25.3 ± 1.4	93.4 ± 7.5	198.8 ± 6.1	60.2 ± 7.5	5.24 ± 0.26	5.30 ± 0.30	28.03 ± 0.60	3.08 ± 0.12	17.0 ± 2.0	2067.0 ± 845.0

WCh = 2016 World 3x3 Championships; ECh = 2016 European 3x3 Championships; u18 = Under 18 2016 World Championships; Pro = Professional 3x3 events. Values are mean ± SD. Performance results from literature are the averages from traditional positions of 'guard' for females and 'forward' for males where elite players were studied3-12. a= different to players at European championships. b= different to players at World championships. c=different to previous traditional 5x5 literature. Only clear differences where the confidence interval overlapped thresholds for substantial positive and negative values (±0.20 standardized units) are indicated.

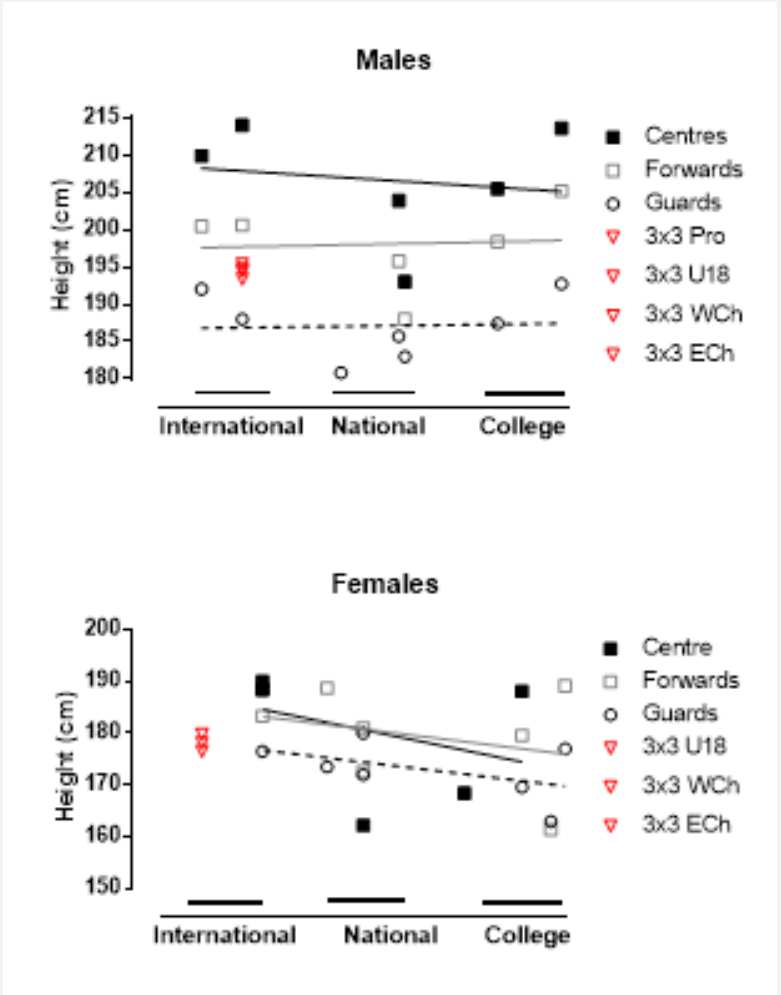

Figure 1: Comparison plot of stature across playing levels for male (top panel) and female (bottom panel) elite 3x3 and traditional basketball players. Lines crossing each level of ability are trend lines.

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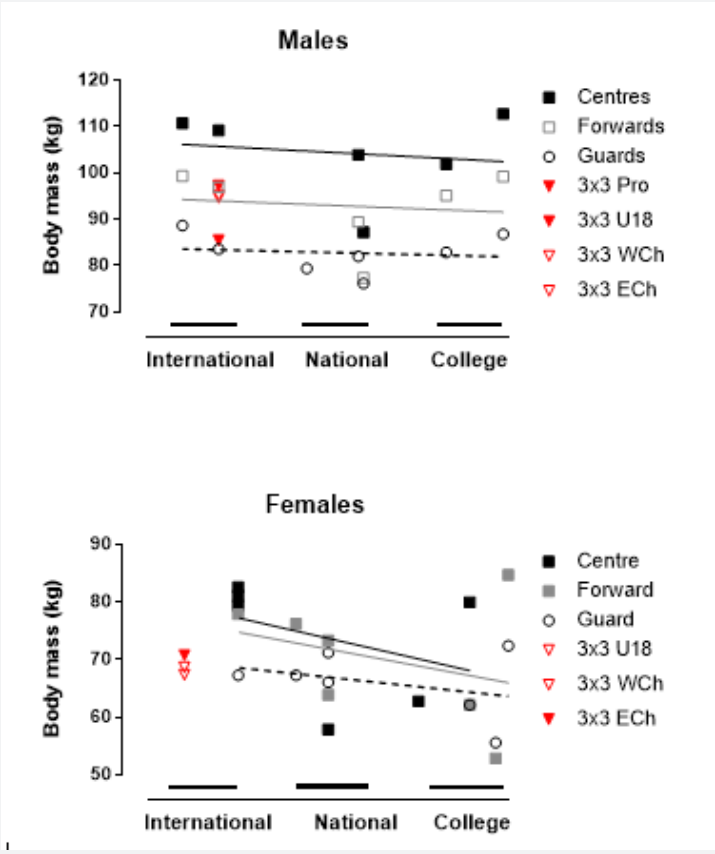

Figure 2: Comparison plot of body mass across playing levels for male (top panel) and female (bottom panel) elite 3x3 and traditional basketball players. Lines crossing each level of ability are trend lines.

Height for male players at the under 18 level showed small but unclear differences compared to European (-0.40; ±0.43, -1.3%), World (-0.26; ±0.34, -0.8%) and trivial difference to professional levels (-0.04; ±0.45, -0.1%). For female 3x3 players, there were small clear differences for players at the under 18 (-0.49; ±0.31, 1.5%) and European level (-0.62; ±0.50, 1.9%) being taller than recorded literature. Male 3x3 players at the under 18 level had moderately lower body mass compared to players at the European (-0.73; ±0.79, 6.3%) and World (-0.95; ±0.94, 8.2%) level, and were moderately lighter compared to literature (-0.73; ±0.71, 6.4%). 3x3 players at the professional level were moderately heavier (0.64; ±5.1, 5.9%) than literature. For female 3x3 players, there were small clear differences for players at the under 18 level (-0.47; ±0.47, 4.8%) having less body mass, and European level (0.41; ±0.58, 4.1%) having greater body mass compared to recorded literature.

For 20m speed, although unclear, male 3x3 players at the under 18 level (-1.0; ±8.21, 5.1%), and World Championships (-0.58; ±1.19, 3.0%) were faster compared to professionals. Compared to the literature, it was clear that 3x3 players at the World championship (0.90; ±0.66, 4.8%) and professional level (1.10; ±0.32, 6.0%) were slower. No other clear differences were found between other groups.

For female 3x3 players, clear moderate and small differences were shown respectively for under 18 (0.99; ±0.54, 5.5%) and World level (0.55; ±0.53, 3.0%) players to be slower compared to results from literature. There were unclear moderate differences in vertical jump performance between male under 18 players compared to players at the European (-1.07; ±2.19, -12.7%) level, and trivial difference to professionals (-0.16; ±0.86, -2.1%) and literature (-0.12; ±0.52, -1.6%). For female 3x3 players, large but unclear differences were seen between under 18 (-1.22; ±0.54, 18%) and World level (-1.86; ±0.90, 26%), and clear moderate differences at the European level (-0.73; ±0.69, 11.2%) compared to available literature. There were clear moderate to large differences in aerobic capacity for males as assessed by the YoYo Level 1; players at World championship level had moderately greater capacity (0.91; ±0.46, 41.2%) compared to under 18 players, and a large difference compared to European championships (1.28; ±1.44, 38.4%). All levels except for World level were lower when compared to the literature, with moderate difference for European (-0.73; ±0.68, 24.2%), and large differences between under 18 (-1.82; ±0.52, 50%) and professionals (-1.42; ±0.52, 41.7%).

For female 3x3 players, small to moderate mostly unclear differences were seen between European and World level (-0.54; ±1.14, -30.3%), and between under 18 and World level (-0.69; ±1.12, -28.5%). Large but mostly unclear differences were seen between under 18 (-1.73; ±0.30, -56.9%) European (-1.65; ±0.45, -55.1%) and World level (-0.30; ±0.65, -13.5%) compared to literature. There were no differences between male 3x3 players

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at the under 18, European or World level. Players at the World level were slower compared to literature by a small but unclear amount (-0.33; ±0.65, 1.7%), and players at professional level were slower by a clear moderate amount (-0.86; ±0.49, 4.4%). For female 3x3 players, only a clear trivial difference was observed between under 18 and World levels (0.03; ±0.21, 0.7%). Very large differences were observed between under 18 (-0.75; ±0.30, -30.4%) European (-0.67; ±0.45, -27.6%) and World level (-0.30; ±0.65, -17.8%) compared to literature. There were no meaningful differences between male players at under 18, European or World level for agility trials performed to the left or right direction. Additionally, there was no difference between trials in both directions. For female 3x3 players, moderate but unclear differences were seen for agility trials in both left (0.92; ±1.24, 5.2%) and right (0.51; ±1.15, 2.8%) directions for under 18 compared to World level. A clear large difference was seen between the under 18 and European level (1.34; ±1.42, 7.6%) for trials to the right only. A large but unclear difference was seen between World and European level (-1.10; ±0.76, -5.8%) for trials to the left only.

Discussion

The purpose of this study was to characterize and describe the physical and physiological attributes of elite 3x3 players competing at international level, across junior and senior levels. To our knowledge, this is the first comprehensive investigation into the attributes of 3x3 basketball players. At the international elite junior and senior levels, male 3x3 players are generally shorter and females taller, and both have greater body mass compared to traditional basketball players, with mass increasing as players move from junior to senior 3x3 levels and compete in World Championships or professional events. Physiologically, when assessed with standard performance tests, there was often little difference between levels for male and female 3x3 players across the international tournaments assessed here, however clear outcomes were shown for several physiological aspects which may reveal that 3x3 players are a cohort of players that have different performance capacities, and this may be related to the differing game demands of 3x3 compared to traditional basketball.

The height of male 3x3 players (Figure 1a) shows that the players assessed at junior and senior level were tightly grouped, and in comparison, to the available literature for traditional players competing at international level, 3x3 male players were similar to players classified as forwards. The previous literature for females (Figure 1b) shows that all traditional positions increase in height as players move to international standard, and that female 3x3 players fall between classifications of guard and forward.

Body mass characteristics for male 3x3 players showed more variation (Figure 2a), with junior players lighter than their senior colleagues, and as players become older and participate at the professional level body mass increases compared to other 3x3 players competing at international levels (Figure 2b). For females, as for height, body mass in traditional basketball increases as players move to international level and the results from this observation show that female 3x3 players resemble perimeter players. The results of a recent study demonstrate that a strong relationship exists between body composition, aerobic fitness, anaerobic power, and positional roles in elite traditional basketball21. Conversely, in anaerobic field and court-sport athletes, maximal power output was most predictive of elite performance, with physical characteristics such as height, weight, percentage body fat, and flexibility having been suggested not as important in athletic performance22. Within 3x3 basketball, given the similarity in physical attributes across the international levels assessed here, body composition may be a characteristic that has less distinction, and is less of a determinant of performance than previously reported14 for traditional basketball. However, as this was the first comprehensive assessment of elite 3x3 players, we did see wide variation for height and mass, although the relevance of height as 3x3 develops may be less important as players and teams focus on the ability to score quickly within the game constraints. Furthermore, size and shape of 3x3 players may be aggregating towards that of shooting guard or forward as described in traditional basketball, as these player types combine attributes of speed, agility and shooting capacity, while still being able to maintain physical strength and contest rebound shots which are important demands in elite 3x3. Although variation was observed in both male and female 3x3 players for height and body mass, it appears that elite 3x3 players may aggregate to specific physical characteristics.

The main finding of a recent study assessing the performance attributes of traditional basketball players across junior to senior levels was a progressive improvement in the physiological capacities of basketball players as age increased23. We have not shown this progression, and that both junior and senior 3x3 players lack certain physiological capacities as expected from basketball players at the elite level, with certain attributes (agility, countermovement jump, repeat effort capacity) having no difference between junior to senior level players, regardless of gender. The speed characteristics over a 20m sprint test of male 3x3 players revealed that regardless of international level or tournament, there was little difference in the players assessed. However, as players increased in age, those competing at World Championship or professional level were slower than previous literature of traditional players. For females the same is true; little difference was shown between levels, but junior and senior players at World level were slower than previous literature. This shows that increasing age may limit performance without appropriate physical and physiological conditioning, but also it should be noted that players can improve this ability. Whether these outcomes are a training and preparation limitation, or an outcome of players specializing and preparing for game demands which are different to that of traditional basketball remains to be seen. Additionally, although there was incentive for players to produce their best efforts in each test, we have to concede that this may not have always been the case and could be a limitation to the outcomes.

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Aerobically, both males and females are relatively poor compared to previous literature but reasonably similar across the cohort measured. Aerobic capacity is an important physiological characteristic necessary for basketball performed at a high level24, and it has previously been shown that the Yo-Yo level 1 may be considered as a valid basketball-specific test for the assessment of aerobic fitness25. The maximal oxygen uptake (VO2max) is the rate at which exercising musculature uses oxygen; the maximum rate at which an individual can consume oxygen is an important determinant in physical work capacity in many sports. A moderate to high VO2max would be required during 3x3 play, as the debilitating effects of anaerobic glycolysis from the repeat-effort demands can be offset by a greater energy provision from aerobic pathways. Anaerobically, when assessed by a repeat-effort running test that stresses the anaerobic energy pathway, both male and female 3x3 players show limitation in this capacity compared to previous literature. Whilst the ability to maintain the repeat-effort nature of 3x3 play may be attributed to several factors, the accumulation of intracellular inorganic phosphate (Pi), and creatine phosphate (PCr) availability appear to be the likely determinants26. The fact that PCr resynthesis, and intracellular Pi removal via phosphorylation are aerobic processes26, suggests that a high VO2max and enhanced anaerobic capacity may augment a 3x3 players ability to resist fatigue during high intensity play. Basketball training can facilitate improved aerobic conditioning27, however, it remains to be determined if the limitation observed here is an artefact of poor preparation, or specific adaptation to 3x3 demands.

It was previously articulated that the focus of performance training in the anaerobic athlete should be on increasing power production, which has a direct correlation with speed and agility22. We revealed that in this cohort there was no relationship between speed and jumping ability in 3x3 players, however it has been indicated that a correlation exists between jumping ability, agility performance and sprint time in young male basketball players28. Additionally, we only observed moderate to large, but unclear differences in agility performance for female players compared across the international tournaments, and no differences for males at any level. Evidently this could indicate that agility is not a performance determinant for 3x3 players, or again is an artefact of the relationship between power, speed and agility not being trained adequately. Given the demands of 3x3 play, these attributes appear favorable, and need to be fully developed across gender and level to ensure success and high level performance.

Conclusion

Elite players competing in the international 3x3 arena display anthropometric characteristics similar to that of some positions described in traditional basketball, however the physiological capacities of 3x3 players can differ compared to these previous reports. In light of the findings of this study, elite 3x3 players should, but do not, possess high aerobic and anaerobic capacities to meet the energetic demands of the 3x3 game. Speed, acceleration and agility are all attributes that would favor success in 3x3 basketball, however 3x3 players appear to also lack in these qualities, with improvement as players move to senior levels not evident. To improve competition success and the standard of 3x3 as an international sport, coaches, individual players and federations should invest in structured and specific strength, and conditioning programs to improve these physical and physiological attributes. Further research is required to determine the physical and physiological demands of 3x3 competition, with particular reference to differences to tournament play.

Practical Implications

a) The prerequisites to compete at the elite international 3x3 level appear to be similar to the performance attributes for most team-sport and court-based sports.

b) Frequent high speed movements in acceleration, deceleration, change of direction and jumping require comprehensive conditioning in power, speed and agility, combined with skill execution in shooting and passing will optimise success.

c) Most notably, general fitness and development of aerobic and anaerobic capacities are lacking at this point in the 3x3 player.

d) Elite players display general physical characteristics similar to that of some positions described in traditional basketball, however the physiological capacities can differ significantly compared to previous reports.

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