

The Physical and Physiological Characteristics of 3x3

Results of Medical Study & Scientific Test

Prepared by

Dr. Paul Montgomery & Brendan Maloney (Aspetar Orthopaedic Hospital)

In cooperation with FIBA Medical Commission

Background and Take-aways

The research – the first of its kind – was conducted in a series of FIBA 3x3 Official Competitions with more than 200 3x3 National Team and World Tour players in the period from December 2015 to end of October 2016 with the objective to scientifically prove the physical and physiological characteristics of 3x3 and the differences to traditional 5v5 basketball as well as to lay a scientific ground for training recommendations. For that purpose the players were taken through a series of basketball specific performance tests and were equipped with heart rate monitors and GPS units in-game during the competition. Furthermore lactate tests and rates of perceived exertion were taken right after each game.

The main take-aways that will be presented here in detail will show that the **demands of a 3x3 game are different to the demands of traditional 5v5 basketball** and that 3x3 players have differing physical and physiological characteristics compared to players from traditional basketball; in particular, the study shows that **3x3 is significantly more anaerobic than traditional 5v5 basketball** and that, while the game is shorter, the relative intensity in 3x3 is twice that of traditional 5v5 basketball.

Another objective of this study is to develop 3x3 specific preparation recommendations and training plans based on the findings of this study.

Index

1. Methods.....	3
2. Outcomes Performance Tests.....	4
2.1 Height.....	4
2.2 Body Mass.....	5
2.3 Speed.....	6
2.4 Vertical Jump.....	6
2.5 Anaerobic capacity.....	8
2.6 Agility.....	9
2.7 Aerobic capacity.....	9
3. Game Demands.....	10
3.1 Heart Rate.....	10
3.2 Lactate.....	11
3.3 Perceived Exertion.....	12
3.4 Player Load.....	13
3.5 Acceleration and Deceleration.....	15
3.6 Jump Profile.....	16
3.7 Change of Direction.....	16
4. Summary.....	17
5. Recommendations.....	18
5.1 Aerobic Fitness.....	19
5.2 Anaerobic Fitness.....	19
5.3 Repeat Sprint Training.....	19
5.4 Agility Training.....	20
5.5 Speed Training.....	20
5.6 Strength Training.....	20
5.7 Recovery.....	21

1. Methods

The research took place in the period from December 2015 to end of October 2016 at the FIBA 3x3 All Stars 2015, the FIBA 3x3 World Tour Final 2016, FIBA World Cups 2016 (U18 and Open) and Europe Cup 2016.

During play, players were asked to wear a personal Global Positioning System (GPS) (Catapult™ Melbourne, Australia), for the standard variables of distance (m) and meters covered per minute of game time (m/min). Total number of game files collected for analysis was 820 from 807 males over 252 games and 635 from 635 females over 85 games.

Blood lactate was sampled as close to the completion of each game as possible (within 2 minutes) via capillary puncture to the earlobe. A total of 238 males and 190 females completed 718 and 584 lactate samples post game respectively.

Heart rate was measured continuously during play through personal chest transmitters and was analysed for peak and average game heart rate (b/min). A total of 145 males and 85 females provided 588 and 383 heart rate responses to games respectively.

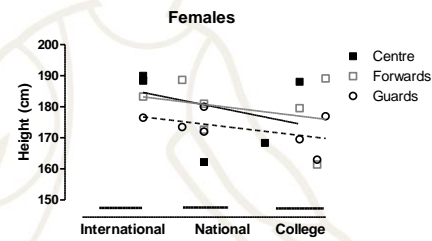
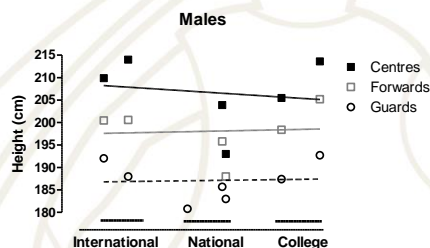
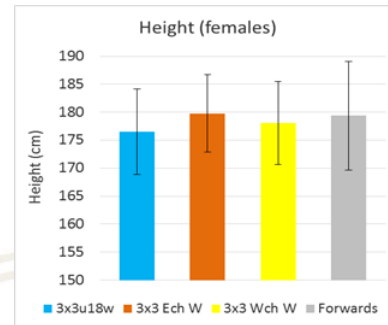
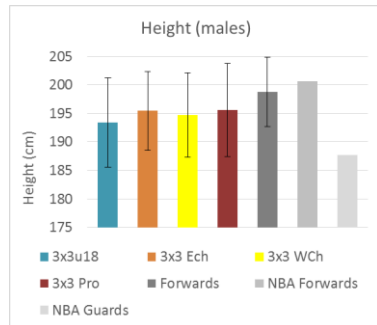
Rates of perceived exertion (RPE) were measured within 2 minutes post game, where players were asked “how hard was that game for you?” A modified Borg CR10 scale which has been used previously and validated was used to determine responses, with 10 being maximal. A total of 143 males and 123 females completed 565 and 520 responses post game respectively.

Participants were asked to complete a series of basketball specific performance tests prior to competition periods, or on the day after their exclusion from a tournament, with a subset of 123 males and 73 female players choosing to participate in the performance testing. These tests have been used extensively within traditional basketball, and were used to describe the physical and physiological characteristics of 3x3 players.

Research results were compared to a database from NBA ‘D’ league players to provide perspective on game demands and also previously published research of physiological responses.

2. Outcomes Performance Tests

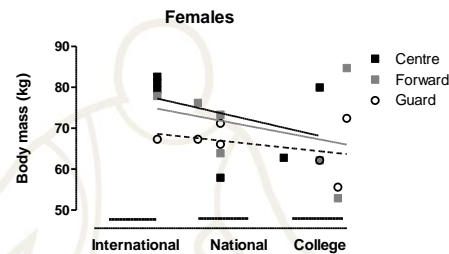
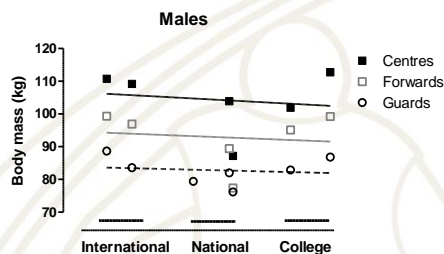
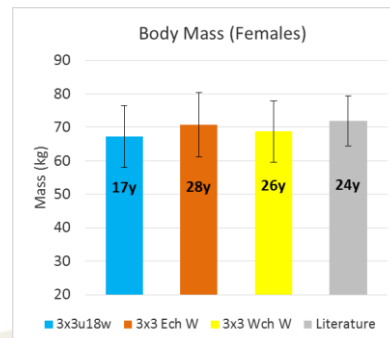
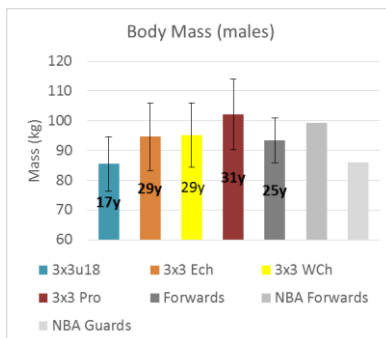
2.1. Height



There is little difference in the height of 3x3 male players across junior to senior levels. Compared to the literature of traditional basketball, 3x3 players are slightly shorter than forwards and shorter again when compared to players drafted as forwards within the NBA draft. The red line in figure 3 shows the comparison of the average height of 3x3 players compared to that of individual positions for international, national and college level players as published in literature.

Junior female players are slightly, but not significantly shorter than senior players and there is no difference of 3x3 female players to information published for height of traditional female players. The average height of 3x3 female players would be the same as that of guards compared to international players in the literature.

2.2. Body Mass



There were substantial differences across junior to senior competition levels for 3x3 males; this appears to be influenced by age as senior players at Europe and World Cups were on average the same age and had no difference in body mass; these players had the same body mass as forwards measured in the literature for traditional basketball, but were older by approximately 4 years. However, the players from professional tournaments were heavier again and approximately another 2 years older. The red line in figure 3 shows the comparison of the average weight of 3x3 players compared to that of individual positions for international, national and college level players as published in literature.

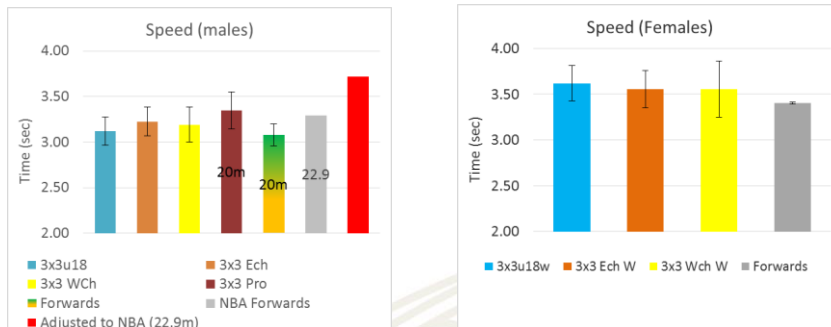
Based on these comparisons, the body size and shape of 3x3 male players are similar to that of players classified as forwards in traditional basketball.

There was no difference across female competition levels, or compared to published information. Weight characteristics of female 3x3 players are similar to that of guards at national and international levels.

In summary, 3x3 male players match the height and weight characteristics of forwards as identified in published literature, however they are generally older; and players who compete in professional competitions are older again and have increased body mass. Female 3x3 players match the height and weight of national and international guards compared to the literature for traditional basketball, and are

2 to 4 years older at senior levels.

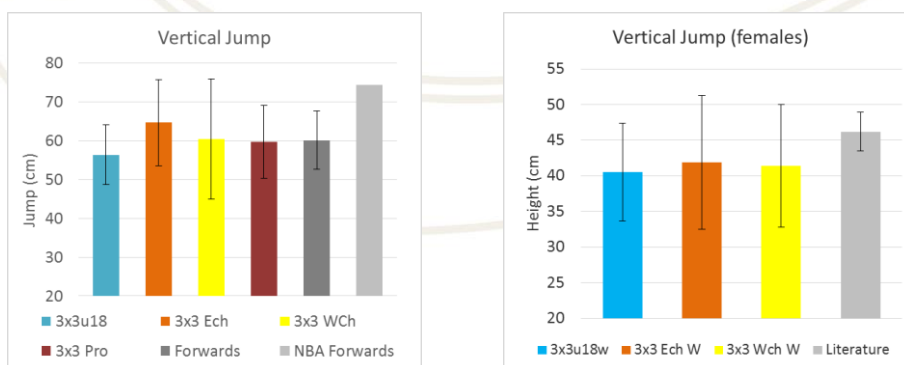
2.3. Speed



Although junior players are only slightly faster, there is little difference in the speed characteristics of 3x3 male players at junior and senior levels, however the older and heavier players who compete at professional levels are marginally slower over 20m. Compared to the literature, all male levels are slightly slower than traditional basketball players tested over 20m, and this difference increases as male 3x3 players get older. Compared to forwards from the NBA who test for speed over 22.9 meters, if the speed from 3x3 male players was adjusted to the same distance, 3x3 male players would be significantly slower. This may represent that 3x3 players cannot maintain speed over longer distances, but have developed unique acceleration characteristics, however this is only speculative as no acceleration information (speed over 5m) is available for a comparison in the literature.

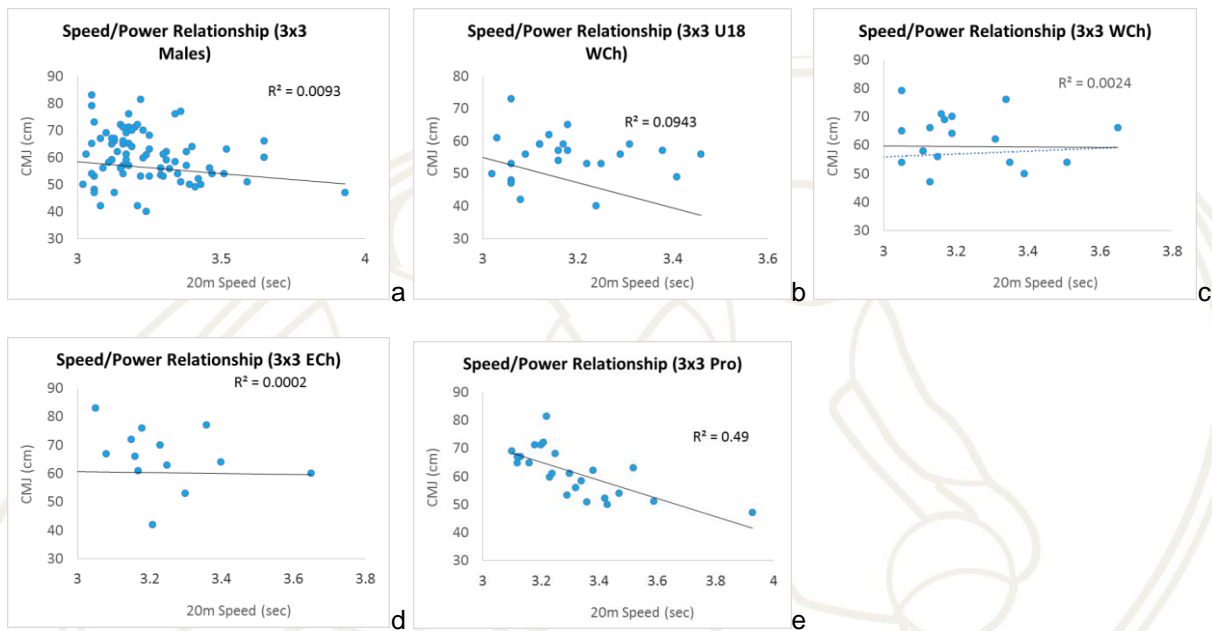
There was no significant difference for speed across junior to senior levels for female 3x3 players, and no difference to information published in the literature.

2.4. Vertical Jump

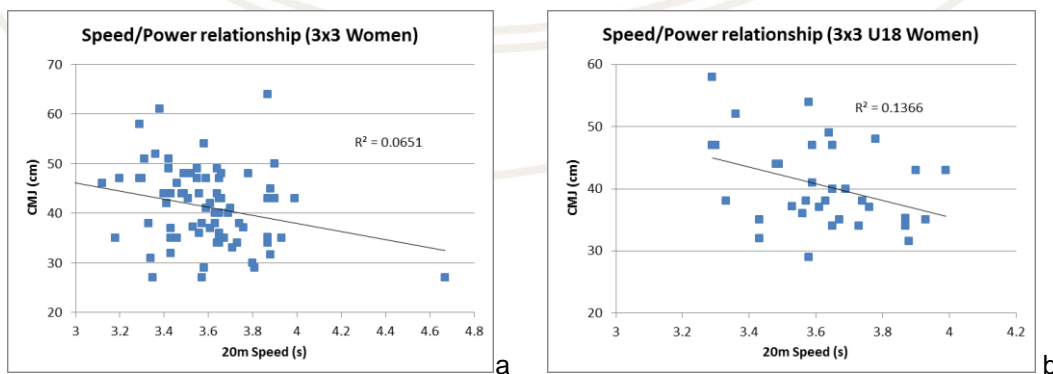


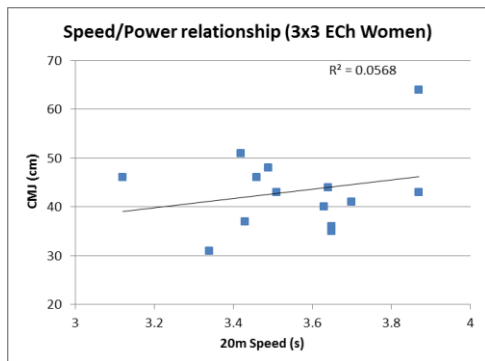
Junior male players have slightly decreased vertical jump (explosive power) ability compared to players measured at other senior levels. 3x3 males are generally the same as that reported for forwards in the literature, but NBA drafted forwards have significantly better vertical jump ability.

There was no significant difference across playing levels for 3x3 female players, but all groups were significantly lower when compared to the literature by approximately 5cm.

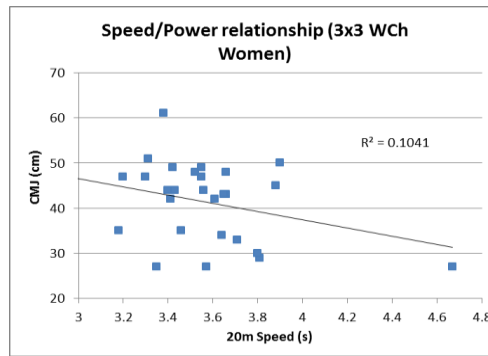


A regression analysis of vertical jump performance against speed shows that overall, explosive leg power when measured by countermovement jump has little impact on speed for male 3x3 players (Figure a). However there are two sub groups (b, e) where there is a slight relationship; for players in junior and professional levels, players with a better vertical jump will have (albeit minor) greater acceleration and speed characteristics.





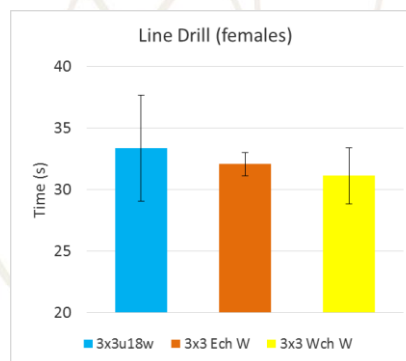
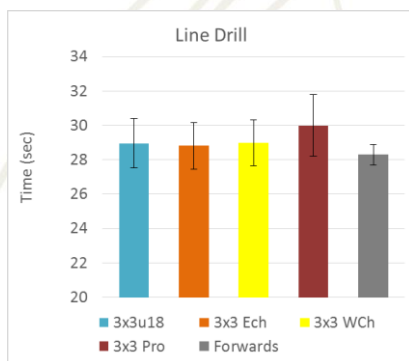
c



d

A similar regression analysis of vertical jump performance against speed shows that overall, explosive leg power when measured by countermovement jump has little impact on speed for female 3x3 players (Figure a). Although there do seem to be better outcomes for females at the U18 and World Cup level, however the relationships are still weak.

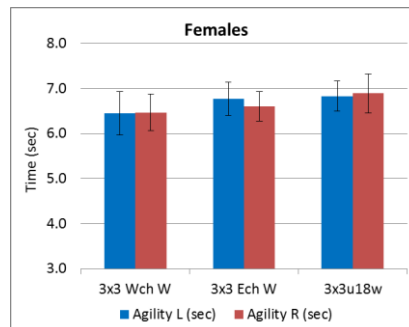
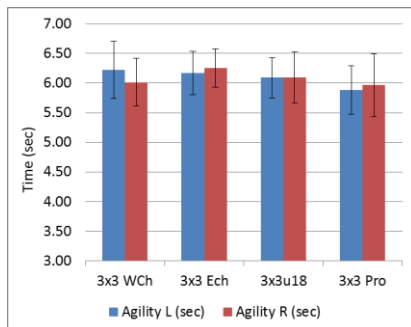
2.5. Anaerobic capacity (Line Drill)



There is no difference in anaerobic capacity (the ability to make repeat efforts) between male junior and senior levels. Again, as players get older in the professional levels the capacity to maintain repeat effort ability decreases by approximately 1 second. Compared to forwards in the literature, 3x3 male players are on average 1 second slower in this performance characteristic.

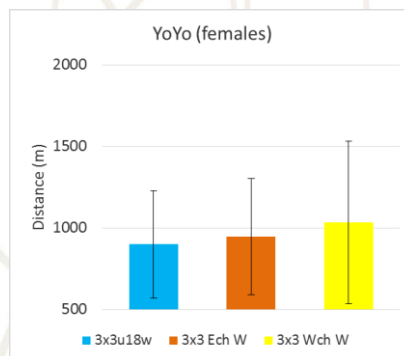
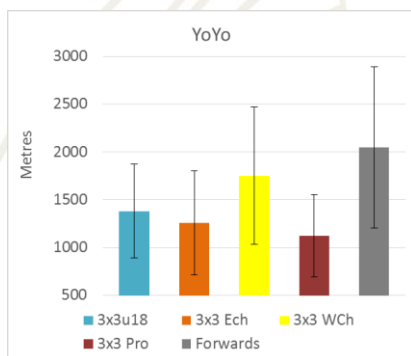
For female 3x3 players, there is approximately 1 second difference between each of the tournaments assessed, and as would be anticipated, performance improves with standard of competition.

2.6. Agility



There was little evidence of a difference in agility performance across junior to senior levels, for both males and female players. There was also no clear difference when players were asked to complete the agility test in opposite directions.

2.7. Aerobic capacity (YoYo test)

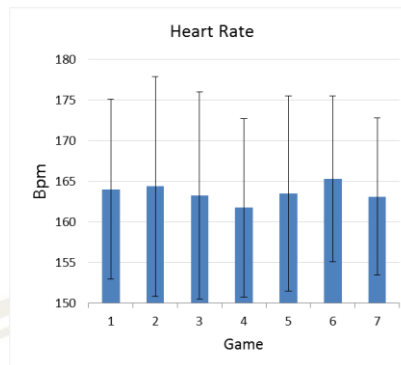
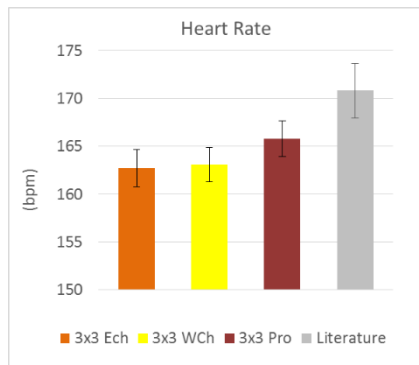


Generally, 3x3 players are poor with respect to aerobic capacity; this capacity appears to decrease with age for males. Male players at professional levels are approximately 50% worse than forwards reported in the literature. On average, players from junior and senior male levels are approximately 25% lower in aerobic capacity compared to players in traditional basketball.

There are trivial differences between females players, with those tested at the World Cups slightly better. For both genders, there is wide variation in ability across all tournaments.

3. Game Demands

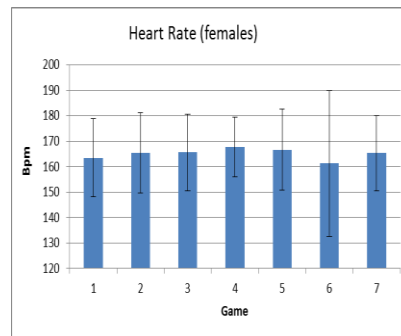
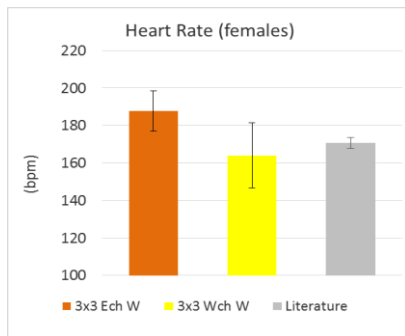
3.1. Heart Rate



The average heart rate response during male 3x3 was not different at Europe and World Cup levels, and only marginally higher at professional competitions. Compared to the heart rate responses recorded from literature, heart rate during all levels of 3x3 are significantly lower.

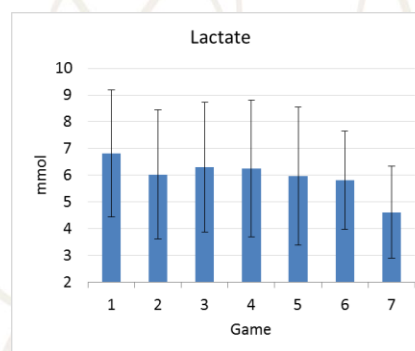
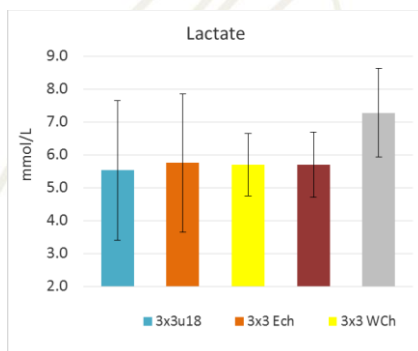
A recent report of traditional basketball describes average heart rates of ~171 beat/min, which was 91% of the maximal heart rate recorded during play. Additionally, during on-court playing periods, 75% of playing time was at or above 85% of maximal heart rate. The average heart rate response during play for 3x3 is 83% of the average peak heart rate obtained from players during competition or testing. Therefore, although the absolute heart rate response from 3x3 players is lower than that of traditional basketball, given that there is less distance travelled during play the relative intensity as a proportion of maximal is similar to that of traditional basketball. This is a unique characteristic as it demonstrates that the requirement to meet the game demands of fast changes in direction, in a small competition space is high.

No differences were observed for heart rate response over increased number of games, and this may be due to the wide variation in responses to game demands. This indicates that as the number of games increases, that heart rate may not provide a clear indication of fatigue.

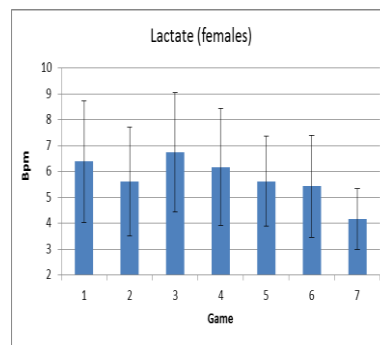
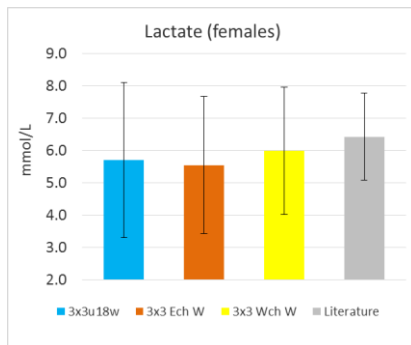


For female players, the average heart rate responses from the Europe Cup were significantly higher than World Cup, and those published from literature. Similar to male responses, there were no differences in heart rate as the number of games increased, and both show wide variation.

3.2. Lactate

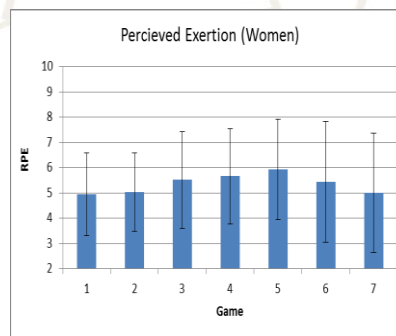
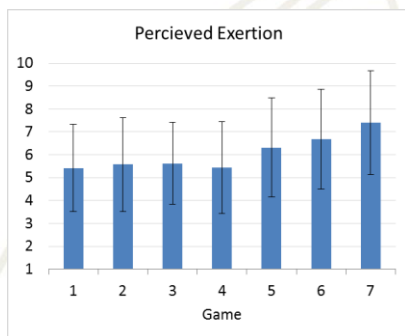


There is no difference in Lactate response across all levels of male 3x3, with moderate amount of variation at senior level. However these responses are lower compared to the lactate responses published in literature for traditional basketball. Lactate is an indirect indicator of anaerobic energy system involvement, and intensity. There is a trend for both male and female lactate levels to decrease over a tournament as the number of games played increases. Decreased lactate response can be an indicator of fatigue as players fail to meet the high intensity demands of play, or may also be an indicator of decreased glycogen stores.



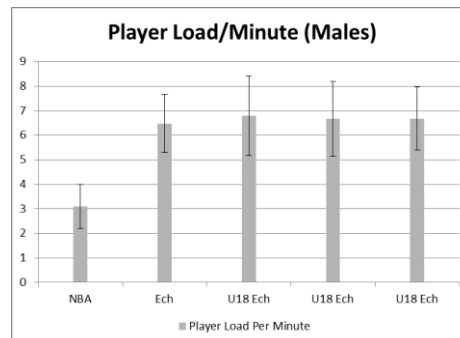
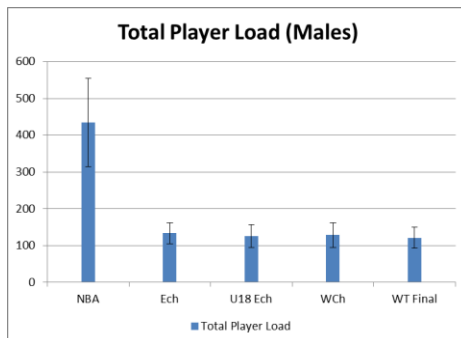
For female players, there was a trivial difference in lactate response across tournaments, and a small difference to those reported in the literature.

3.3. Perceived Exertion (RPE)



The rate of perceived exertion (RPE) is a subjective measure where players are asked “how hard was that game for you?” and they respond on a 10 point scale, with 10 being maximal effort. The results show that there are wide individual responses to this assessment, and the perceived effort it takes to play elite 3x3. There is a trend for RPE responses to increase over a tournament as the number of games played increases, for both males and females. This is understandable as the standard and intensity of games as team’s progress to finals would be expected to increase; it may also be an indicator of fatigue as teams are required to play several finals games in one day.

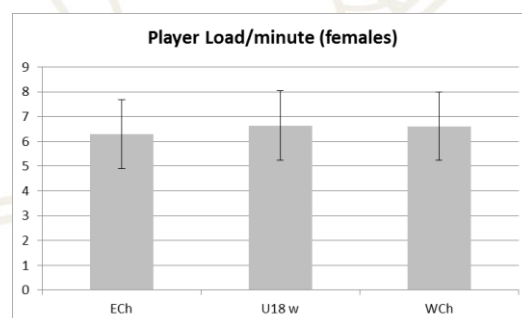
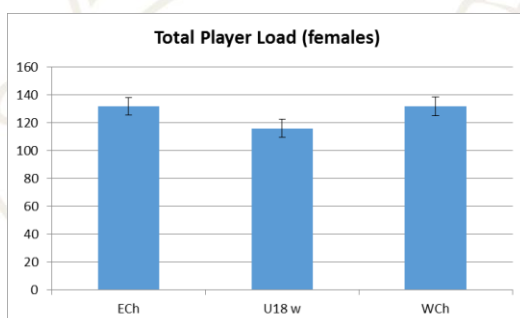
3.4. Player Load



Player load is a method that assesses the whole body movements of competition which are accumulated over the game. This estimate of the physical demands of 3x3 combines the instantaneous rate of change in acceleration for the three planes of body movement; up/down, side/side, and forward/backward. As this measure accumulated over time, Player Load is divided by game time to express the relative intensity. This allows differing periods of competition to be evaluated consistently.

The average Player load measures between NBA D (435.3 ± 120.4) and 3x3 (128.2 ± 39.6) are significantly different. However, this can be explained by the amount of additional distance that traditional basketball players cover compared to that of 3x3; traditional players on average may cover ~4500 m compared to 870 m in 3x3 (but maybe up to 1470m). This difference would be most heavily influenced by forward motion, particularly the amount during transition up and down the court.

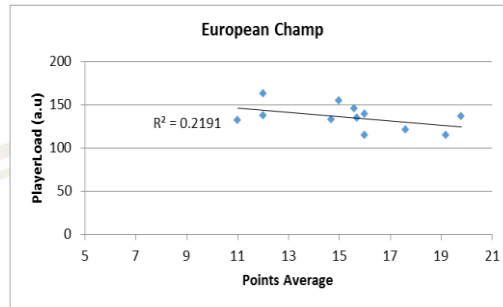
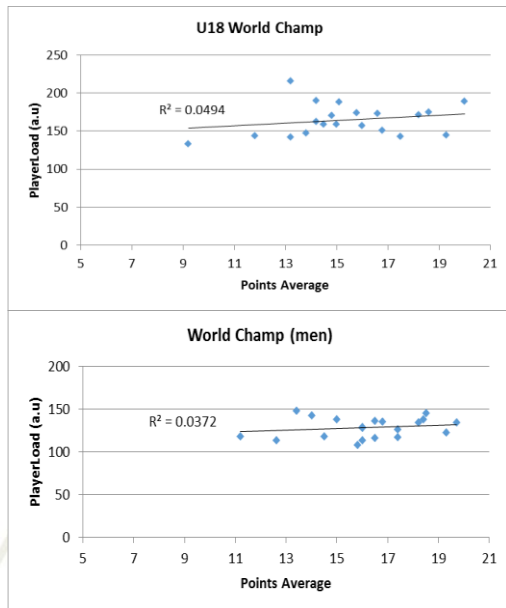
When Player Load is evaluated relative to time, the relative intensity of male 3x3 (6.7 ± 1.5) is approximately twice that of traditional basketball (3.10 ± 0.9).



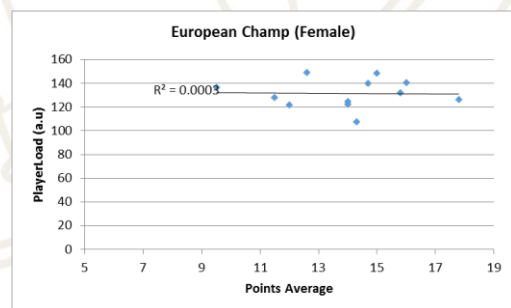
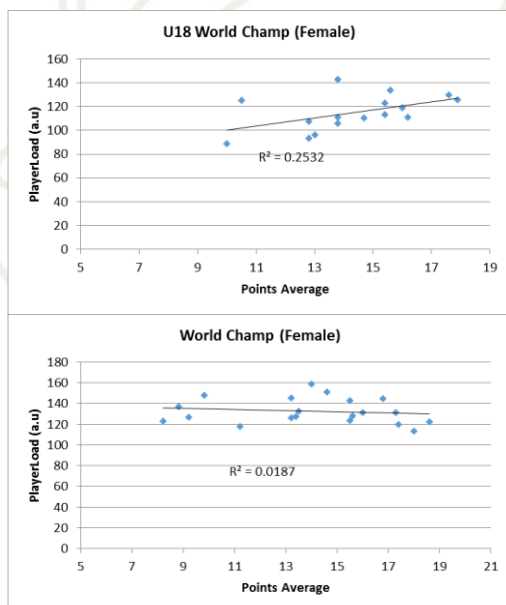
Interestingly, female player load (126.4 ± 29.9) and player load/minute (6.5 ± 1.4) was no different to that of male players. This is a unique feature of 3x3; in that the movement demands are similar in both male and female competition.

Success in 3x3 does not appear to be related to work rate (Player Load), as there were weak relationships between finishing higher in a tournament or the average number of points scored, and this was consistent for the other main work variables of Player load per minute, meters per minute and distance covered. Therefore success may be more related to skill, in particular the ability to score quickly.

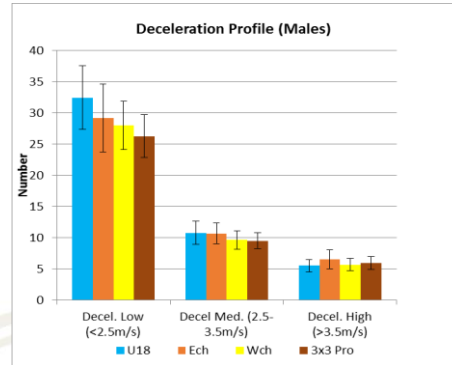
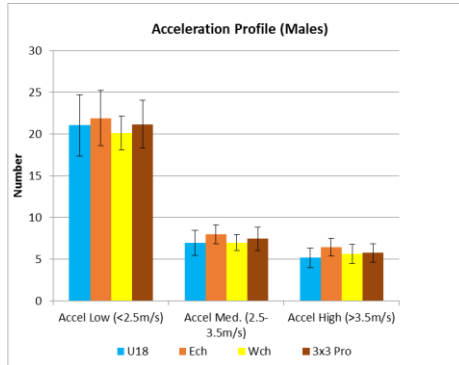
Males:



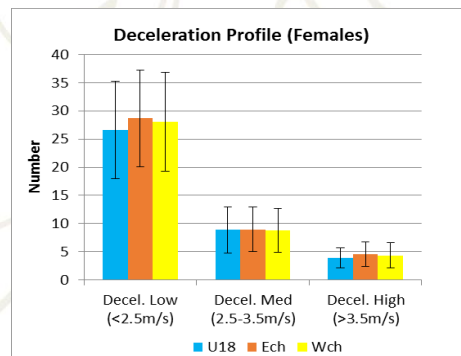
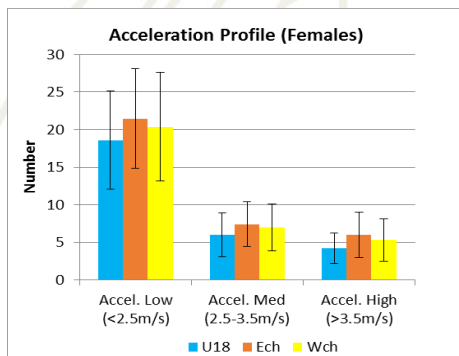
Females:



3.5. Acceleration and Deceleration

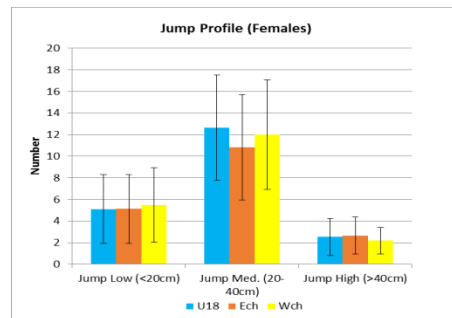
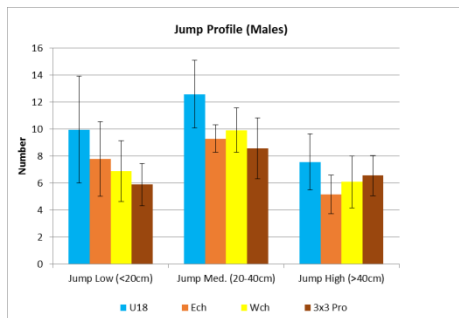


There was no difference in the average number of accelerations for male players across tournament and ages. However there is a significantly higher number of decelerations, particularly in the low to medium range, but not at the high speed range. This indicates that the demands of 3x3 require a high number of deceleration movements which has consideration for physical preparation.



The acceleration and deceleration profile for females is similar to that of males, displaying that there are a greater number declaration events, particularly in the low and medium range, with no difference for high speed accelerations and decelerations. Surprisingly, the volume of high speed accelerations and decelerations are similar between males and females, which appears to be a unique aspect of 3x3 in that high speed movement is not gender specific.

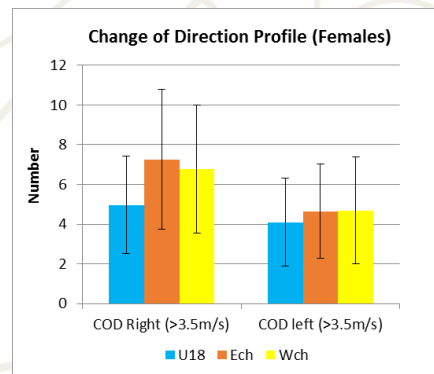
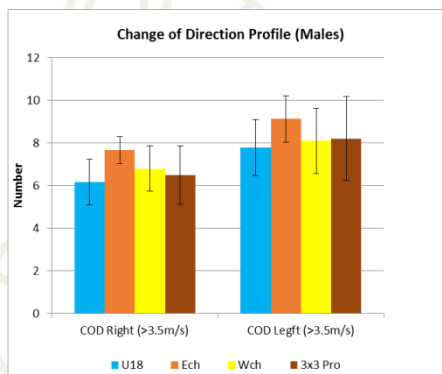
3.6. Jump Profile



The in-game jump profile for males is varied across age and tournament. Junior players completed a higher number of jumps across all ranges. For all groups, the greatest amount of jumps occurred in the medium range of 20-40cm indicating that the requirement within 3x3 may not be to produce maximal jump height, but repeated jumps at a competitive height.

Females complete a dramatically less amount of average jumps per game compared to males, and these are of moderate height, indicating that the female game is not very explosive in the vertical plane.

3.7. Change of Direction



Apart from the Europe Cup, there was a significant difference in the change of direction profile for male players; males tend to make a greater number of fast changes in direction to the left. The reasons for this are not achievable in this analysis.

For female players, the volume of fast changes of direction is lower than males, and it appears the main change of direction are to the right, but only for European and World tournaments. This coincides with the other physical and physiological data, in

that the female game is less explosive than males.

4. Summary

The majority of the outcomes discussed here are related to the data collected from males due to the lack of comparative information available for females. The data presented for females is descriptive, and the first to be documented for 3x3 players; comparisons are made between levels where possible.

- 3x3 players have differing physical and physiological characteristics compared to players from traditional basketball, but are generally consistent across age groups for the tournaments and players measured here.
- Male 3x3 players are generally shorter and heavier and more closely resemble forwards from traditional basketball, while female players are similar to the characteristics of guards at national and international level.
- Although males have similar explosive leg power to that of forwards in traditional basketball, females present with less ability when assessed by vertical jump, this does not translate to speed as male and female 3x3 players are slower than published data.
- There was no significant difference for speed across junior to senior levels for both male and female 3x3 players.
- The repeat effort ability of 3x3 players is also less than that of the literature, and this deteriorates with age.
- Aerobically, 3x3 players are poor compared to the literature, with the capacity of some playing groups being 25-50% below that of traditional basketball.
- Male and female players are generally consistent with their ability to change direction quickly, with little influence from a players preferred side (handedness).
- The physiological responses of heart rate and lactate in male 3x3 are unique and lower than that observed in the literature of traditional basketball; however female 3x3 players can have higher responses than that previously published for traditional basketball.
- Although 3x3 players cover far less distance during a game compared to traditional basketball, the heart rate response as a percentage of maximal is high, and similar to that of traditional basketball. This is also true of lactate, indicating that although players must compete in a confined space, the higher relative intensity of these movement demands contribute to relatively high lactate responses.
- The inertial movement assessment performed using accelerometer data was the first to be collected for 3x3. The total player load, and relative

intensity show that the movement demands are similar during both male and female competition, the differences in other physiological measures of heart rate and lactate are gender specific.

- Acceleration and deceleration profiles during male and female 3x3 are gender specific, with females lower in volume and speed, while both genders complete more deceleration activities during a game.
- The relative intensity of male competition is twice that of traditional basketball.
-

Recommendations to improve performance for 3x3 players are that aerobic capacity should be developed to underpin the high intensity training to meet game demands, and the high intensity of games; this can be met through specific physiological, and game/skills based conditioning. Improve agility by completing specific drills, and speed ability through appropriate strength to meet multiple games. Passing and shooting appear to be high skill requirements. Players should also focus on recovery elements to meet the demands of multiple games in one day, and multiple days of competition.

5. Recommendations

- Improve aerobic and anaerobic capacity
- Improve agility and speed ability
- Improve strength to meet game and tournament demands, and injury prevention

As 3x3 can be considered as predominantly anaerobic exercise, players compete in a confined court area increasing the relative movement intensity compared to traditional basketball. Increased high intensity accelerations and decelerations from change of direction movements contribute to this difference. This also demonstrates a dissociation between displacement (distance covered) and intensity in the demands to play 3x3 i.e. although there is less total distance covered and the metres covered per minute of game time is low, the actions described drive a high physiological response.

The ability to perform short, repeat efforts comprising multiple changes in direction in a confined court space is complex and multifactorial. The importance of both aerobic and anaerobic energy pathways has been shown in traditional basketball, and likewise in our analysis of 3x3. Additionally, lower body strength and neuromuscular power are key contributors to performance in repeat effort and change of direction activities.

The purpose of these recommendations is to improve the performance of 3x3

players while also decreasing the likelihood of injury.

5.1. Aerobic Fitness

From our analysis, and comparison to traditional basketball, we have shown that 3x3 players have low aerobic capacity. There is a high importance of aerobic capacity in relation to repeat effort and high intensity change of direction movements.

The aerobic energy system contributes to the restoration of the anaerobic energy system, which we have shown is heavily involved in meeting the energy demands of 3x3.

Practically, the quicker players can recover between efforts, or during a substitution period, performance in the next on-court period will be maintained. Players wishing to increase their performance should spend a proportion of their training time dedicated to increasing aerobic fitness.

General aerobic conditioning can be achieved through methods of running, cycling and swimming i.e. basic fitness principles, and these can be completed at slow to moderate pace for 30 – 60 minutes. However, training drills that are specific (scrimmage drills - 1v1, 2v2, 3v3) or High Intensity Interval Training (HIIT) in nature will meet the explicit demands of 3x3. These should reflect a training prescription of long intervals of 1-4 minutes performed @ 90-95% of maximal heart rate, with a work rest ratio of 2:1 (e.g. 2 minute work interval: 1 minute rest period). This form of HIIT should be at, or close to maximal effort.

5.2. Anaerobic Fitness

Traditional basketball is characterized by shorter duration, high intensity change of direction activity in which performance is mainly dependent on the player's anaerobic capacity. The high relative player intensity (player load per minute) and high peak lactate values observed in our analysis of 3x3 also reflects this anaerobic fitness requirement.

Training for anaerobic power requires maximum intensity efforts which are characterized by short HIIT with intervals less than 60 seconds.

5.3. Repeat Sprint Training

Repeated short sprints lasting between 6 - 10 seconds with recovery periods lasting approximately 60 seconds are effective in developing repeat sprint ability. The main

focus of this type of interval training is to decrease the fatigue deficit between sprints, and ensure that the slowest sprint is within a specific range of the fastest sprint.

5.4. Agility Training

Specific 3x3 agility drills will improve speed around the court, foot quickness, coordination and most importantly the ability to change direction with minimal deceleration. Just as important is the ability to rapidly switch between forward, backward, lateral and vertical movements.

Integrating the agility drills below within a speed, and strength training program will have a dramatic impact to performance. Not only will players be able to move around the court much more quickly, the ability to transfer much, or all of that energy into other specific movements such as jumping.

Basketball agility drills are great for combining physical AND mental awareness. Combine basketball agility drills with other speed, and strength training sessions. Together they will help to significantly increase quickness and quality of movement around the court.

5.5. Speed Training

For 3x3, the emphasis is switched to acceleration, and to a lesser degree deceleration; therefore the duration of the maximal sprint efforts decreases to 5 – 10 seconds, and long passive recovery is taken between sprints to ensure that quality of each interval is at or very close to maximum capacity.

5.6. Strength Training

Strength training is an important part of any preparation for elite sport. It is not only prescribed to develop pure strength, but also for injury prevention, which in itself is performance enhancing. Strength training should be prescribed 2 to 4 times per week depending on the competition schedule i.e. more sessions in the preparation phase and less session for maintenance during competition.

Periodisation of Strength Training

- Periodisation can be defined as the structure of the strength training over the competitive season. Typically, volume will be high and relative load will be low during the preseason to build a solid strength base and increase muscle size with an increase in body weight through hypertrophy training.

- As the season progresses to towards the competitive phase the volume will reduce and the relative load will increase using more explosive and power orientated programme.

Bar Speed and Muscular Failure

Two important considerations when carrying out strength training is the speed at which the exercise is carried out and whether or not the lifter reaches muscular failure during the exercise.

- Resistance training exercise can be performed maximally or sub-maximally which has an effect on muscle adaptation. Maximal intent to move the weight as fast as possible when lifting is very important in increasing strength and power during resistance training.
- Performing resistance training to failure should be used sparingly as the fatigue from this type of training is high and can have a negative impact on recovery and subsequent training sessions. Alternatively, players should lift close to failure with the ability to lift 1 or 2 more repetitions before failing in that set. This will allow more weight to be lifted in the following sets and limit non-functional fatigue.

5.7. Recovery

Nutritional recommendation:

In tournament and between matches, players should focus on gaining adequate carbohydrate and protein to replenish stores depleted by the competition. Sport drink will be the easiest way to replenish carbohydrate during and between games, but players are well advised to seek whole foods to ensure complete restoration when daily games are finished; this includes well balanced plates of food that have combinations of carbohydrate, protein and leafy greens. Players should aim to keep fluid loss within 2% of body weight. A simple strategy can be measuring a pre- and post-match body weight and replacing fluids as necessary.

Stretching:

3x3 players should complete regular (daily) flexibility sessions. Players should limit static stretching before matches as excessive stretching can interfere with the muscles maximal power production which often causes a temporary reduction in performance.

Focus should be placed on mobility and drills to allow maximum joint mobility.