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Abstract

Competition-specific conditioning for tournament basketball games is challenging, as the demands of tournament formats are not well characterized. ***Purpose***: To compare the physical, physiological and tactical demands of seasonal and tournament basketball competition, and determine the pattern of changes within an international tournament. ***Methods***: Eight elite junior male basketball players (age 17.8 ± 0.2 y, height 1.93 ± 0.07 m, mass 85 ± 3 kg; mean ± SD) were monitored in six seasonal games played over four months in an Australian second-division national league, and in seven games of an international under-18 tournament played over eight days. Movement patterns and tactical elements were coded from video and heart rates recorded by telemetry. ***Results***: The frequency of running, sprinting and shuffling movements in seasonal games was higher than in tournament games by 8-15% (99% confidence limits, ±~8%). Within the tournament, jogging and low to medium intensity shuffling decreased by 15-20% (±~14%) over the seven games, while running, sprinting and high-intensity shuffling increased 11-81% (±~25%). There were unclear differences in mean and peak heart rates. The total number of possessions was higher in seasonal than in tournament games by 8% (±10%). ***Conclusions***: Coaches should consider a larger emphasis on strength-power training in their conditioning programs to account for the higher activity of seasonal games. For tournament competition, strategies that build a sufficient aerobic capacity and neuromuscular resilience to maintain high-intensity movements need to be employed. A focus on half-court tactics accounts for the lower number of possessions in tournaments.

Keywords: coaching, training, motion analysis, physical performance, sport, sport physiology

Introduction

The development of elite junior basketball players needs to be tailored towards the physiological, physical, and tactical demands of seasonal domestic competition or tournament-style international competition or both. A targeted training program is best planned and implemented if the specific demands of domestic and international competition are well characterized. To date, several investigations have described the physical and physiological demands of seasonal competition[1-13] where players typically play one game each week, but not tournament-style competition involving multiple games in a seven to ten day period. Fatigue effects and higher level opposition in tournaments may require a different preparation than seasonal competition. The lack of research in tournament competition is surprising considering this format is followed in international championships (under 17, under 19, and senior World Championships) sanctioned by the International Basketball Federation (FIBA).

Physical demands of seasonal basketball games have been primarily investigated through time-motion analysis quantifying various low to high intensity movement patterns. A high number of movement patterns occur during standard seasonal basketball competitions in male athletes (~1000 ± 100 total movement patterns;[3,7] mean ± SD). Movement changes are recorded on average every 2-3 seconds[3,7] often involving frequent changes in direction and rapid deceleration and acceleration of the body.[5] Work-to-rest ratios of ~1:4 indicate short bouts of moderate to high intensity physical activity followed by longer periods of recovery.[2] Higher movement intensities have been observed in higher levels of seasonal competition (national versus state)[11] and in higher level athletes.[1] In contrast, the physical demands of international tournament competition remain unclear.

Male basketball athletes maintain high mean heart rate values (>85% of maximum heart rate) for the majority of live playing time.[2,7] Higher mean heart rate values are exhibited during international level compared to national level female competition,[1,10] however the physiological demands of higher levels of male competition have not been investigated. Elite male junior players have shown higher mean heart rates than sub-elite players within the same competition.[1] The effect of tournament competition on physiological demands estimated via heart rate monitoring remains to be investigated. Characterizing changes in heart rate throughout multiple games should give insight into the physiological demands experienced during a tournament.

Successful teams typically have more successful field goals and are able to exert more defensive pressure than their opponents.[14,15] The tactical elements that lead to this advantage remain uncertain. It appears that winning teams gain more defensive rebounds facilitating more fast breaks.[16] The importance of fast breaks for winning seems to be equally important in modern seasonal competition.[17] While fast breaks increase scoring opportunities, a larger proportion of the game is played using a more controlled set offence.[17,18] In regard to the efficiency of different elements of set offences, only limited research has been conducted. The use of an “inside-outside” game in set offensive patterns of play is important.[19] The frequency and value of other patterns of play remain to be investigated. A comparison of the different styles of play between the two competition formats should provide useful tactical information for coaches and support staff.

International basketball competition predominately involves a tournament-style competition format. Tournaments are characterized by a large number of games in a short time period (e.g. eight games in ten days). Despite the importance of international championships and rankings, no investigation to date has examined the various physical, physiological and tactical demands of this competition format. Differences in demands between seasonal and tournament competition, as well as changes over the duration of a tournament should reveal important information for coaches and support staff.

The aim of this study was to quantify and compare the physical, physiological and tactical demands of international tournament competition versus seasonal national-level competition in elite U19 male basketball players. A secondary aim was to identify patterns of change in these demands within tournament competition. Understanding the demands of international championships will allow coaches and support staff to better implement long-term preparation plans around seasonal demands, as well as strategies within a tournament.

Methods

The experimental design comprised a cross-sectional (seasonal versus tournament competition) and longitudinal (changes in demands within tournament competition) study of elite male junior basketball competitions. Data were collected from a seasonal national senior men's 2nd division winter competition (2010 South East Australian Basketball League, Australia) and a friendly international under 19 tournament including 16 national teams (2010 Albert Schweitzer Tournament, Mannheim, Germany). Six national seasonal (all home games) and seven international tournament games were analyzed. The seasonal games were played at least one week apart over a four month period, and the tournament games within an eight day period which took place during the season. Both competition types used the same game format with 4x10 min quarters and equal rest periods. Data were analyzed to compare the two competition formats, as well as changes within international tournament competition.

Subjects

Eight elite junior male basketball players (age 17.8 ± 0.2 y, height 1.93 ± 0.07 m, mass 85 ± 3 kg; mean ± SD) were members of both teams that competed in the national league and international tournament. These players had been identified as the most talented junior basketball players in Australia and obtained a basketball scholarship at the Australian Institute of Sport (AIS). Players typically completed over 20 hours of training per week, of which ~5 hours included physical conditioning, and competed at the highest level in national junior competition. Ethical approval was given by the AIS Ethics Committee, approval number 20090805. Informed (parental) consent was obtained from all participating subjects.

Procedures

The physical, physiological and tactical demands of games were quantified through time-motion analyses, heart rate telemetry and video coding software. Heart rate profiles were captured through heart rate telemetry (SuuntoTM, Vantaa, Finland). Heart rates were analyzed for total game time (including time outs, substitution, quarter and half times) and active playing time (including heart rate data above 70% of individual maximum heart rate). Rest periods were not excluded from total game time as was done in previous studies [2,3,6,7,12] to incorporate the effect of rest periods on the physiological demands. Values were expressed as the mean and peak heart rate as a percentage of each subject's individual maximum heart rate (HRmax), time spent in Zone 1 (50-59% of HRmax), Zone 2 (60-69% of HRmax), Zone

3 (70-79% of HRmax), Zone 4 (80-89% of HRmax), and Zone 5 (90-100% of HRmax). HRmax was determined during the Yo-Yo Intermittent Recovery Test Level 1[20] conducted prior to commencement of the study as part of routine physical testing.

Physical and tactical demands were quantified using notational video analysis with specialist sports coding software (SportsCode Elite, Sydney, Australia). The physical demands were quantified as the count of the following movement patterns: stand-walk, jog, run, sprint, low, medium and high intensity shuffle and jumps.[3,7] Our time-motion analysis showed moderate to good reliability with typical errors ranging between 3.8% and 15% and intraclass correlations from 0.68 to 0.93 across the different movements. Briefly, jogging was defined as forward movement involving a flight phase without urgency, while running involved moderate urgency and a more pronounced arm swing. Sprinting efforts were forward movements with high to maximal intensity. Shuffling was defined as any sideways or backwards movement from low to high intensity.

Tactical demands were quantified as the number of offensive technical elements within a game. The elements within offensive possessions were coded as outlined in Table 1. Both teams employed the same coaching staff and tactical strategies in seasonal and tournament competition allowing a comparison of the tactical demands between the two competition formats. Duration of each possession for the home and opposition team and the transition time between possessions were used to calculate work-to-rest ratios. The total duration of multiple possessions with a short transition phase (<30 sec) was determined as a "playing period". A time exceeding 30 seconds between possessions was defined as a "break period". Possessions with durations below eight seconds were defined as a "fast break", indicating a quick transitional style of play in offence. All data shown are standardized to 30 min playing time (physical demands) or to 100 possessions (tactical demands).

<<Insert Table 1 here>>

Statistical Analysis

Player movement, heart rate data and tactical elements were analyzed with a Poisson regression model that accounted for any linear time-dependent trends during the season and within the tournament. Values at the midpoint of the tournament were estimated for comparisons of seasonal versus tournament competition. Movement counts were expressed per 30 min of movement time to allow comparisons between and within competitions, and tactical elements were standardized to 100 possessions to account for differences in game rhythm.

Inferential analyses were based on uncertainty in magnitudes of effects to overcome the shortcomings associated with traditional statistical significance testing.[21] Uncertainty in effects is indicated with 99% confidence limits. Effects were deemed unclear if the confidence interval overlapped the thresholds for smallest important increases and decreases of counts or durations, which were assumed to be 10% (a factor of 1.10).[22] Smallest important changes for peak and mean heart rate values (expressed as percent of HRmax) were 0.5% and 1% for peak and mean heart rate respectively, which were approximately 0.2 x between-subject standard deviation.[22] Magnitudes of clear effects were described probabilistically using the following scale: possibly 25-75%, likely 75-95%, very likely 95-99.5%, and most likely >99.5%.[23]

Results

All games played by the Australian team at the Albert Schweitzer tournament were highly competitive. The team lost one game by 5 points at the start of the tournament but managed to win all other games with close margins and finished the competition in first place. Seasonal games were mostly competitive with the team winning two games and losing two by close margins (point differential <12 points). Two games in the seasonal competition were lost by slightly larger margins (17 and 23 points). A summary of the descriptive mean and standard deviation data for the physical, physiological and tactical demands is shown in Table 2 for both national seasonal and international tournament competition. For the tactical demands, possession, rest, playing and break duration refer to the cumulative mean duration of both teams' possessions, i.e. mean durations for every possession of the game. All other tactical elements refer to the investigated team only. Possession and rest durations are standardized to one possession. Playing and break durations are standardised to one count of playing and break periods.

Physical demands

The difference in the total number of movements at the mid-point of the tournament was trivial (-7.1%, ±3.8%; mean, ±99% confidence limits) between season (788, ±43) and tournament (732; ±40) competition. Running, sprinting and low to high intensity shuffling type movements occurred more frequently (8-15%, ±~8%) in seasonal games compared to tournament competition (Figure 1). Differences in other movement categories between the two competition formats were trivial. Substantial decreases during the international tournament occurred in jogging, low intensity and medium intensity shuffling. Conversely, the frequency of running, sprinting and high intensity shuffling increased substantially during the tournament (Figure 2).

<<insert Figure 1 & Figure 2 here>>

Physiological demands

Thirty-four heart rate data sets were incomplete due to belts falling off during games. Only complete game files were analyzed from six players with a total of 75 individual heart rate data sets. Peak heart rate values were possibly different between seasonal (94 ± 3 % of maximum heart rate; mean ± SD) and tournament (95 ± 2 % of maximum heart rate) competition. There were possible differences in mean heart rate between the two competitions for total game time (67.1 ± 6.6 % vs. 68.1 ± 5.8 % of maximum heart rate) or active playing time (84.3 ± 1.8 vs. 83.9 ± 2.3 % of maximum heart rate). When comparing time spent in different heart rate zones, players likely spent 32% (±99% confidence limits, ±17%) more time in Zone 1 and possibly 7% (±12%) more time in Zone 4 in seasonal, but possibly 11% (±16%) more time in Zone 2 and 12% (±14%) more time in Zone 3 in tournament competition. No clearly substantial difference in time spent in Zone 5 was evident between the competition formats.

There was no clear change in peak heart rate over the duration of the tournament and clearly trivial changes in peak heart rate during the season. In contrast, the mean heart rate during active playing time possibly increased (1.4, ±1.8 %) by the end of the tournament. The higher mean heart rate coincided with a likely 30% (±29%) increase in time spent in Zone 4 and a likely 21% (±17%) decrease in time spent in Zone 3 during the tournament.

Tactical demands

The mean duration of a possession in seasonal competition was 7% (±99% confidence limits, ±9%) shorter than the tournament competition. The mean rest duration between possessions was also 20% (±27%) shorter in seasonal than tournament competition. Accordingly, the total number of possessions was 8% (±10%) higher in seasonal competition compared to tournament competition. The higher number of possessions corresponds with 16% (±13%) more fast breaks (possessions < 8 sec) in seasonal competition. The mean playing periods were similar between seasonal and tournament competitions with no clear differences between the two competitions. The mean break duration was 20% (±16%) longer in tournament games than seasonal games. These mean playing and break durations reveal ~1.5 min of work, followed by 1 min of recovery throughout a basketball game.

Differences in the frequency of different offensive demands between seasonal and tournament competition were largely unclear. Seasonal competition showed a substantially higher number of ball reversals and dribble penetration. The frequency of hand-offs increased substantially (47-50%, ±~45%) during tournament and seasonal competition, whereas the number of post entries substantially decreased over the season (71%, ±35%). Ball reversals and indirect screens occurred most frequently in both types of competition (Figure 3). The duration of possessions (10%, ±12%) and playing periods (62%, ±48%) increased during the tournament.

<<insert Table 2 here>>

Discussion

This is the first research project to compare differences and patterns in the physical, physiological and tactical demands of seasonal and tournament competition in basketball. Overall, seasonal games show a higher intensity in physical demands indicating a faster, more stochastic game. Tournament competition entails fewer low intensity movement patterns, but more high intensity movements as the competition progresses. The smaller number of possessions in tournament games is consistent with observations that the international tournament involved a more controlled offensive and defensive style of play. The differing physical and tactical demands between seasonal and tournament competition highlight the need for specific training programs of basketball players for the two competition formats. Additionally, strategies limiting the effects of cumulative fatigue on movement patterns in tournament competition need implementing.

The descriptive findings from this research extend previous reports on the physical and physiological demands of male basketball competition. With 24-26 movements per min in seasonal and tournament competition, the total number of movements (~1000) within a game and the frequency of changes in movement every ~2 seconds are comparable to the movement patterns reported in other male basketball games using standard time-motion analysis.[3,7] These results may underestimate the frequency in change in movement as a more sensitive frame by frame time-motion analysis and additional movement categories revealed ~twice the total movement frequencies.[1,11] The higher frequency of high intensity movements in seasonal games likely reflects the advantage of being fresh physically for each single game with minimal cumulative fatigue effects from previous games. These physical demands in seasonal competition indicate the need for basketball players and coaches to have a larger focus on frequent high-intensity efforts in conditioning practices. Since repeat sprint ability is

linked to anaerobic capacity,[24,25] conditioning this metabolic pathway may need to take precedence in preparation for seasonal competition. The other possible explanation for the higher proportion of running and sprinting in seasonal games is the style of play. The higher number of possessions in seasonal games indicates a faster style of offensive game. We consider that international basketball requires a higher more structured level of defense and offense which decreases the number of possessions. We interpret the decrease in the number of low intensity movements (jogging, low to medium intensity shuffling) during tournament competition as indicative of cumulative fatigue.[26] Conversely, the frequency of high intensity movements (running, sprinting, high intensity shuffling) increased. There are two possible explanations for the increase in high intensity movements in tournament competition. First, as tournament competition progresses into the final stages the quality of the opposition increases which may necessitate more frequent high intensity movements to be successful. Cognitive fatigue may be another factor that results in delayed responsiveness and a need to increase work rates to make up for slower decision making processes. These findings emphasize the importance of players having the ability to produce high intensity efforts over the length, and especially towards the end, of a tournament. Long-term development for tournament competition in junior players should incorporate sufficient aerobic and neuromuscular conditioning to minimize fatigue effects and maximize recovery between games. Short-term strategies may include frequent player substitutions during games and post-game recovery interventions such as massage, fluid and macronutrient replenishment, and possibly cold-water immersion.[26-28]

The physiological demands measured during seasonal and tournament competition reflect previous findings of peak heart rate values (~95% of HRmax) in junior male players,[3] as well as high mean heart rate values (~84% of HRmax) during playing time.[3,6,7,12] The heart rate values measured during both seasonal and tournament competition confirms the high physiological demands experienced during basketball games. The greater amount of time spent in Zone 2 (moderate intensity) in tournament competition may reflect short-term fatigue from tournament play.[29] Coaches and support staff need to be aware of the magnitude and effects of short-term fatigue from tournament play when planning training and competition strategies. Within a tournament competition the physiological demands correspond with the increase in high intensity movement patterns. An increase of time spent in Zone 4 (high intensity) and mean heart rate over the tournament points towards higher cardiovascular demands as the tournament progresses.

Both seasonal and tournament competition show mean playing and break periods of ~1.5 and 1 min, respectively. These data indicate the need for basketball athletes to have the metabolic capacity to be highly active for short periods of time (seconds to minutes) and then replenish energy stores within a short rest period. Contemporary practice of Australian basketball players involves conditioning towards three min periods (unpublished data). Our results indicate a 1.5-2 min period may be more specific for basketball competition.

The deployment of tactics and strategies presumably has a substantial influence on the outcome of international tournaments. Although most leading nations undertake some form of scouting of opposition teams the analysis of tactical demands is rarely available in the public domain. The longer mean duration in possession indicates a different style of play in international tournament competition. This difference presumably reflects a higher level of opposition in international tournaments able to deny early scoring opportunities via more developed team defensive structures. A larger emphasis on more controlled half-court tactics

may be more productive in tournament competition. In terms of tactical elements during offense, our analysis reveals that ball reversals, indirect screens, dribble penetration and ball screens were the four most frequently executed elements of an Australian-style offence in both forms of competition. The high number of ball reversals indicates the importance of shifting the ball from one side of the court to the other in order to disrupt the opposition's defense. The higher frequency of dribble penetration in seasonal competition may be related to a faster style of play allowing players to attack the key area more frequently. Having a focus on dribble penetration could be more conducive to the faster style of seasonal games. Guards are required to dribble more frequently than forwards and centers and should focus on their ball handling and dribble penetration in particular.[11,12] Future research employing video-based assessment of tactical demands will clarify the offensive and defensive tactics associated with successful teams in both junior and senior competitions.

Practical Applications and Conclusions

The physical preparation for tournament-style play may need to be modified in comparison with that of seasonal competition. Coaches and support staff need to adjust conditioning programs towards the higher movement frequency of seasonal compared to tournament games. Preparing athletes for seasonal competition should involve a larger focus on high intensity interval training to increase the anaerobic capacity of basketball players. Work periods of ~1.5-2 min with a 1 min recovery for interval-based training would be game-specific in this context. To maintain physical performance in the latter stages of tournament competition, coaches should implement strategies to offset the effects of fatigue. Long-term preparation should develop physical attributes needed to recover from game to game. Short-term strategies may include frequent player substitutions during games and post-game recovery interventions. Fatigue management strategies can play a particularly important role in tournament play since better recovery may allow for greater use of faster styles of play against a fatigued defense.

From a tactical standpoint, seasonal competition involves a higher number of possessions than tournaments. Preparation for seasonal competition should have a larger emphasis on the tactical requirements for a faster style of game. Conversely, possessions last longer in tournament competition and highlight the need for structured half-court tactics. Improving skills to perform efficient ball reversals, i.e. passing and leading should have priority in developing elite junior basketball players. Further attention should then be given to indirect screening, ball screens and dribble penetration.

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Figures & Tables

Figure 1 – Differences in physical demands of seasonal and tournament basketball competitions expressed as standardized differences (%). The differences are derived from the means and SD as shown in Table 1. Shaded areas indicate magnitude of effect.

Figure 2 – Change (%) in movement counts during an international junior basketball tournament competition. Shaded areas indicate magnitude of effect.

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Table 1 - Tactical elements coded during offensive possessions to evaluate tactical demands of seasonal and tournament basketball competition

Ball reversal	Defined as ball movement from one side of the court to the other. An imaginary line between both baskets, often referred to as the "splitline", is used to divide the court into two sides. Every ball movement across this splitline was considered a ball reversal. Ball reversals force the defense to move from one side of the court to the other, enabling better scoring opportunities.
Dribble penetration into the key area	A player dribbling or receiving the ball off a cut with at least one foot inside the key area was defined as dribble penetration.
Post entry	The post is a position on the court around or in the key area. A pass from another position to the post area is defined as a "post entry" that increases the likelihood of scoring opportunities close to the basket.
On-ball screen	Offensive pattern involving a player standing in the way of a teammate's defender who is guarding the ball carrier. The teammate who is carrying the ball can then separate from his defender while dribbling the ball to create an offensive advantage.
Hand off	Similar concept to on-ball screen where an exchange of the ball between players occurs by directly handing over the ball to a team mate.
Off-ball screen	Involves an offensive player standing in the way of a team mate's defender. This screening action allows the other offensive player to separate from his defender.

Table 2 – Physical, physiological and tactical demands of national season and international tournament competition (mean ± SD).

	Season	Tournament
Physical demands (counts.30min^{-1})[a]		
Total movements	809 ± 80^{00}	758 ± 106
Stand-walk	255 ± 32^{000}	252 ± 34
Jog	102 ± 23^{00}	99 ± 28
Run	90 ± 17*	82 ± 15
Sprint	33 ± 7**	28 ± 8
Low shuffle	94 ± 15**	80 ± 24
Medium shuffle	193 ± 33*	175 ± 41
High shuffle	26 ± 9*	24 ± 9
Jump	19 ± 6^{00}	19 ± 5
Physiological demands (min)		
Time in zone 1	34 ± 22***	26 ± 28
Time in zone 2	14 ± 7.0	16 ± 7.1*
Time in zone 3	8.5 ± 2.8	10 ± 3.8*
Time in zone 4	17 ± 5.2*	17 ± 5.9
Time in zone 5	7.1 ± 6.5	6.5 ± 6.4
Tactical durations (s)		
Possession duration	14 ± 3	15 ± 3*
Rest duration	12 ± 5	14 ± 5*
Playing duration	96 ± 9	102 ± 9
Break duration	58 ± 6	65 ± 6*
Tactical demands (counts.100possessions^{-1})		
Possessions	94 ± 9*	87 ± 10
Total Elements	248 ± 60	220 ± 36
Fast breaks	23 ± 3**	20 ± 4
Ball reversal	87 ± 26**	72 ± 15
Ball screen	32 ± 11	28 ± 8
Dribble penetration	44 ± 7*	37 ± 7
Hand off	21 ± 7	16 ± 3
Indirect screen	57 ± 19	60 ± 25
Post entry	6 ± 5	7 ± 2

[a]Counts per 30 min of active playing time.

Superscripts denote clear comparisons of season with tournament games, as follows:

*possibly greater, **likely greater, ***very likely greater,

^{0}possibly similar, ^{00}likely similar, ^{000}very likely similar.

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