Activity Profiles and Demands of Seasonal and Tournament Basketball Competition

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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 6 seasonal games played over 4 mo in an Australian second-division national league and in 7 games of an international under-18 tournament played over 8 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 7 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 stronger emphasis on strength and 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

The development of elite junior basketball players needs to be tailored toward 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, where players typically play 1 game each week, but not tournament-style competition involving multiple games in a 7- to 10-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 that this format is followed in international championships (under-17, under-19, and senior World Championships) sanctioned by the International Basketball Federation. 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; mean ± SD). Movement changes are recorded on average every 2 to 3 seconds, often involving frequent changes in direction and rapid deceleration and acceleration of the body. Work-to-rest ratios of ~1:4 indicate short bouts of moderate- to high-intensity physical activity followed by longer periods of recovery. Higher movement intensities have been observed in higher levels of seasonal competition (national vs state) and in higher-level athletes. 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. Higher mean heart-rate values are exhibited during international-level than during national-level female competition; 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 subelite players in the same competition. 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. The tactical elements that lead to this advantage remain uncertain. While winning teams gain more defensive rebounds, facilitating more fast breaks. The contribution of fast breaks to winning seems to be equally important in modern seasonal competition. While fast breaks increase scoring opportunities, a larger proportion of the game is played using a more controlled set offense. In regard to the efficiency of different elements of set offenses, only limited research has been conducted. The use of an “inside–outside” game in set offensive patterns of play is important. The frequency and value of other patterns of play remain to be investigated. A comparison of the different styles of play between the 2 competition formats should provide useful tactical information for coaches and support staff.

International basketball competition predominantly involves a tournament-style competition format. Tournaments are characterized by a large number of games in a short time period (eg, 8 games in 10 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 under-19 male basketball players. A secondary aim was to identify patterns of change in these demands in 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 vs 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 second-division winter competition (2010 South East Australian Basketball League) and a friendly international under-19 tournament including 16 national teams (2010 Albert Schweitzer Tournament, Mannheim, Germany). Six national seasonal (all home games) and 7 international tournament games were analyzed. The seasonal games were played at least 1 week apart over a 4-month period, and the tournament games within an 8-day period that took place during the season. Both competition types used the same game format with 4 × 10-min quarters and equal rest periods. Data were analyzed to compare the 2 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 had obtained basketball scholarships 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 time, and halftime) 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, 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) and 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 conducted before 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. Our time–motion analysis showed moderate to good reliability, with typical errors ranging from 3.8% to 15% and intraclass correlations from .68 to .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 backward movement from low to high intensity.
Tactical demands were quantified as the number of offensive technical elements in a game. The elements in 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 2 competition formats. Duration of each possession for the home and opposition teams 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 s) was determined as a playing period. A time exceeding 30 seconds between possessions was defined as a break period. Possessions with durations below 8 seconds were defined as a fast break, indicating a quick transitional style of play in offense. All data shown are standardized to 30 minutes playing time (physical demands) or to 100 possessions (tactical demands).

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 minutes 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. 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). Smallest important changes for peak and mean heart-rate values (expressed as percent of HRmax) were 0.5% and 1%, respectively, which were approximately 0.2 × between-subjects standard deviation. Magnitudes of clear effects were described probabilistically using the following scale: possibly 25% to 75%, likely 75% to 95%, very likely 95% to 99.5%, and most likely >99.5%.

Results

All games played by the Australian team at the Albert Schweitzer tournament were highly competitive. The team lost 1 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 2 games and losing 2 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, that is, 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 1 possession. Playing and break durations are standardized to 1 count of playing and break periods.

Table 1  Tactical Elements Coded During Offensive Possessions to Evaluate Tactical Demands of Seasonal and Tournament Basketball Competition

<table>
<thead>
<tr>
<th>Element</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Ball reversal</td>
<td>Ball movement from 1 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 2 sides. Every ball movement across this splitline was considered a ball reversal. Ball reversals force the defense to move from 1 side of the court to the other, enabling better scoring opportunities.</td>
</tr>
<tr>
<td>Dribble penetration into the key area</td>
<td>A player dribbling or receiving the ball off a cut with at least 1 foot inside the key area.</td>
</tr>
<tr>
<td>Post entry</td>
<td>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, which increases the likelihood of scoring opportunities close to the basket.</td>
</tr>
<tr>
<td>On-ball screen</td>
<td>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.</td>
</tr>
<tr>
<td>Hand-off</td>
<td>Similar concept to on-ball screen where an exchange of the ball between players occurs by directly handing over the ball to a teammate.</td>
</tr>
<tr>
<td>Off-ball screen</td>
<td>Involves an offensive player standing in the way of a teammate’s defender. This screening action allows the other offensive player to separate from his defender.</td>
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</tbody>
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Table 2: Physical, Physiological, and Tactical Demands of National Season and International Tournament Competition (Mean ± SD)

<table>
<thead>
<tr>
<th>Physical demands (counts per 30 min)*</th>
<th>Season</th>
<th>Tournament</th>
</tr>
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<tr>
<td>total movements</td>
<td>809 ± 80††</td>
<td>758 ± 106</td>
</tr>
<tr>
<td>stand-walk</td>
<td>255 ± 32††</td>
<td>252 ± 34</td>
</tr>
<tr>
<td>jog</td>
<td>102 ± 23††</td>
<td>99 ± 28</td>
</tr>
<tr>
<td>run</td>
<td>90 ± 17*</td>
<td>82 ± 15</td>
</tr>
<tr>
<td>sprint</td>
<td>33 ± 7**</td>
<td>28 ± 8</td>
</tr>
<tr>
<td>low-intensity shuffle</td>
<td>94 ± 15**</td>
<td>80 ± 24</td>
</tr>
<tr>
<td>medium-intensity shuffle</td>
<td>193 ± 33*</td>
<td>175 ± 41</td>
</tr>
<tr>
<td>high-intensity shuffle</td>
<td>26 ± 9*</td>
<td>24 ± 9</td>
</tr>
<tr>
<td>jump</td>
<td>19 ± 6††</td>
<td>19 ± 5</td>
</tr>
</tbody>
</table>

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 ± 8.8  | 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 per 100 possessions)

| 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    |
| handoff                               | 21 ± 7     | 16 ± 3    |
| indirect screen                       | 57 ± 19    | 60 ± 25   |
| post entry                            | 6 ± 5      | 7 ± 2     |

Note: Symbols denote clear comparisons of season with tournament games, as follows: *possibly greater, **likely greater, ***very likely greater, †possibly similar, ††likely similar, †††very likely similar.

a Counts per 30 min of active playing time.

Physical Demands

The difference in the total number of movements at the midpoint of the tournament was trivial (–7.1%, ±6.8%; mean, ±99% confidence limits) between season and tournament competition. Running, sprinting, and low-to-high-intensity shuffling-type movements occurred more frequently (8–15% ± 8%) in seasonal games than in tournament competition (Figure 1). Differences in other movement categories between the 2 competition formats were trivial. Substantial decreases during the international tournament occurred in jogging and low- and medium-intensity shuffling. Conversely, the frequency of running, sprinting, and high-intensity shuffling increased substantially during the tournament (Figure 2).
Physiological Demands

Thirty-four heart-rate data sets were incomplete due to belts falling off during games. Only complete game files were analyzed from 6 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 2 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 competition 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 in 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 than in tournament competition. The higher number of possessions corresponds with 16% (±13%) more fast breaks (possessions ≤8 s) in seasonal competition. The mean playing periods were similar between seasonal and tournament competitions, with no clear differences between the 2 competitions. The mean break duration was 20% (±16%) longer in tournament games than seasonal games. These mean playing and break durations reveal ~1.5 minutes of work followed by 1 minute 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 handoffs 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. The duration of possessions (10%, ±12%) and playing periods (62%, ±48%) increased during the tournament.

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 for basketball players for the 2 competition formats. In addition, strategies limiting the effects of cumulative fatigue on movement patterns in tournament competition need to be implemented.

The descriptive findings from this research extend previous reports on the physical and physiological demands of male basketball competition. With 24 to 26 movements per minute 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 approximately 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 that 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 2 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 in order 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 toward 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 postgame recovery interventions such as massage, fluid and macronutrient replenishment, and possibly cold-water immersion.

The physiological demands measured during seasonal and tournament competition reflect previous findings of peak heart-rate values (~95% of HRmax) in junior male players, as well as high mean heart-rate values (~84% of HRmax) during playing time. The heart-rate values measured during both seasonal and tournament competition confirm 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. 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 toward higher cardiovascular demands as the tournament progresses.

Both seasonal and tournament competition show mean playing and break periods of ~1.5 and 1 minute, 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 in a short rest period. Contemporary practice of Australian basketball players involves conditioning toward 3-minute periods (unpublished data). Our results indicate that a 1.5- to 2-minute period may be more specific for basketball competition. Our results indicate that a 1.5- to 2-minute period may be more productive in tournament competition and highlight the need for basketball training and competition strategies to offset the effects of fatigue. Long-term strategies may include frequent player substitutions during games and postgame 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, that is, 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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References

11. Scanlan A, Dascombe BJ, Reaburn P. A comparison of the
rate response to game-play in professional basketball players.
15. Sampaio J, Lago C, Drinkwater EJ. Explanations for the
United States of America’s dominance in basketball in
2010;28(2):147–152. doi:10.1080/02640410903380486
16. Tsamourtzis E, Salonikidis K, Taxildaris K, Mawromatis
2002;1:54–58.
17. Tsamourtzis E, Karypidis A, Athanasiou N. Analysis of
team activity in basketball. SPORTAS. 2006;61(2):5–11.
game in World Basketball: comparison between European
Recovery Test: a useful tool for evaluation of physical
22. Hopkins WG. Linear models and effect magnitudes for
research, clinical and practical applications. Sportsscience.
2010;14:49–57.
Progressive statistics for studies in sports medicine and
PubMed doi:10.1249/MSS.0b013e31818cb278
maximal aerobic power and the ability to repeat sprints
in young basketball players. J Strength Cond Res.
25. Hoffman JR. The influence of aerobic capacity on anaero-
bic performance and recovery indices in basketball players.
inflammation, and recovery interventions during a 3-day
250. doi:10.1080/17461390802251844
27. Delextrat A, Calleja-Gonzalez J, Hippocrate A, Clarke
ND. Effects of sports massage and intermittent cold-water
immersion on recovery from matches by basketball players.
02640414.2012.719241
10.1080/02640410802104912
29. Bosquet L, Merkri S, Arvisais D, Aubert AE. Is heart rate
a convenient tool to monitor overreaching?: a systematic

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