

1-1-2013

Activity profiles and demands of seasonal and tournament basketball competition

Markus J. Klusemann

David B. Pyne

Will G. Hopkins

Eric J. Drinkwater
Edith Cowan University

Follow this and additional works at: <https://ro.ecu.edu.au/ecuworks2013>



Part of the [Sports Sciences Commons](#)

[10.1123/ijsp.8.6.623](https://ro.ecu.edu.au/ecuworks2013/668)

Accepted author manuscript version reprinted, by permission, from Klusemann, M., Pyne, D., Hopkins, W., & Drinkwater, E. J. (2013). Activity profiles and demands of seasonal and tournament basketball competition. *International Journal of Sports Physiology and Performance*, 8(6), 623-629. © Human Kinetics, Inc. Article available [here](#). © Human Kinetics, Inc.

This Journal Article is posted at Research Online.
<https://ro.ecu.edu.au/ecuworks2013/668>

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36

Journal: International Journal of Sports Physiology and Performance

Title of the Article (85 character limit incl. spaces):

Activity profiles and demands of seasonal and tournament basketball competition

Submission Type: Original Investigation

Authors: Markus J. Klusemann^{1,2,3}, David B. Pyne¹, Will G. Hopkins⁴, Eric J. Drinkwater²

¹Physiology, Australian Institute of Sport

²School of Human Movement Studies, Charles Sturt University

³Basketball Australia

⁴Auckland University of Technology

Corresponding author's contact details:

Markus J. Klusemann
Physiology, Australian Institute of Sport
PO Box 176, Belconnen, ACT 2616, Australia
Phone: +61 2 6214 1126
Fax: +61 2 6214 1904
Mob: +61 435 451099
markus.klusemann@ausport.gov.au
mklusemann@gmx.de

Preferred Running Head (40 character limit incl. spaces):

Demands of basketball competition

Abstract Word Count: **243** words

Text-Only Word Count: **3520** words.

Number of Figures and Tables: 2 figures, 2 tables

37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64

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 \pm 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, $\pm\sim 8\%$). Within the tournament, jogging and low to medium intensity shuffling decreased by 15-20% ($\pm\sim 14\%$) over the seven games, while running, sprinting and high-intensity shuffling increased 11-81% ($\pm\sim 25\%$). 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% ($\pm 10\%$). **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 competition¹⁻¹³ 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 ($\sim 1000 \pm 100$ total movement patterns;^{3,7} mean \pm 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 $\sim 1:4$ 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.

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

120
121 The aim of this study was to quantify and compare the physical, physiological and tactical
122 demands of international tournament competition versus seasonal national-level competition
123 in elite U19 male basketball players. A secondary aim was to identify patterns of change in
124 these demands within tournament competition. Understanding the demands of international
125 championships will allow coaches and support staff to better implement long-term
126 preparation plans around seasonal demands, as well as strategies within a tournament.

127 128 **Methods**

129
130 The experimental design comprised a cross-sectional (seasonal versus tournament
131 competition) and longitudinal (changes in demands within tournament competition) study of
132 elite male junior basketball competitions. Data were collected from a seasonal national senior
133 men's 2nd division winter competition (2010 South East Australian Basketball League,
134 Australia) and a friendly international under 19 tournament including 16 national teams (2010
135 Albert Schweitzer Tournament, Mannheim, Germany). Six national seasonal (all home
136 games) and seven international tournament games were analyzed. The seasonal games were
137 played at least one week apart over a four month period, and the tournament games within an
138 eight day period which took place during the season. Both competition types used the same
139 game format with 4x10 min quarters and equal rest periods. Data were analyzed to compare
140 the two competition formats, as well as changes within international tournament competition.

141 *Subjects*

142
143 Eight elite junior male basketball players (age 17.8 ± 0.2 y, height 1.93 ± 0.07 m, mass 85 ± 3
144 kg; mean \pm SD) were members of both teams that competed in the national league and
145 international tournament. These players had been identified as the most talented junior
146 basketball players in Australia and obtained a basketball scholarship at the Australian
147 Institute of Sport (AIS). Players typically completed over 20 hours of training per week, of
148 which ~5 hours included physical conditioning, and competed at the highest level in national
149 junior competition. Ethical approval was given by the AIS Ethics Committee, approval
150 number 20090805. Informed (parental) consent was obtained from all participating subjects.

151 *Procedures*

152
153 The physical, physiological and tactical demands of games were quantified through time-
154 motion analyses, heart rate telemetry and video coding software. Heart rate profiles were
155 captured through heart rate telemetry (SuuntoTM, Vantaa, Finland). Heart rates were
156 analyzed for total game time (including time outs, substitution, quarter and half times) and
157 active playing time (including heart rate data above 70% of individual maximum heart rate).
158 Rest periods were not excluded from total game time as was done in previous studies^{2,3,6,7,12}
159 to incorporate the effect of rest periods on the physiological demands. Values were expressed
160 as the mean and peak heart rate as a percentage of each subject's individual maximum heart
161 rate (HRmax), time spent in Zone 1 (50-59% of HRmax), Zone 2 (60-69% of HRmax), Zone

162 3 (70-79% of HRmax), Zone 4 (80-89% of HRmax), and Zone 5 (90-100% of HRmax).
163 HRmax was determined during the Yo-Yo Intermittent Recovery Test Level 1²⁰ conducted
164 prior to commencement of the study as part of routine physical testing.

165
166 Physical and tactical demands were quantified using notational video analysis with specialist
167 sports coding software (SportsCode Elite, Sydney, Australia). The physical demands were
168 quantified as the count of the following movement patterns: stand-walk, jog, run, sprint, low,
169 medium and high intensity shuffle and jumps.^{3,7} Our time-motion analysis showed moderate
170 to good reliability with typical errors ranging between 3.8% and 15% and intraclass
171 correlations from 0.68 to 0.93 across the different movements. Briefly, jogging was defined
172 as forward movement involving a flight phase without urgency, while running involved
173 moderate urgency and a more pronounced arm swing. Sprinting efforts were forward
174 movements with high to maximal intensity. Shuffling was defined as any sideways or
175 backwards movement from low to high intensity.

176
177 Tactical demands were quantified as the number of offensive technical elements within a
178 game. The elements within offensive possessions were coded as outlined in Table 1. Both
179 teams employed the same coaching staff and tactical strategies in seasonal and tournament
180 competition allowing a comparison of the tactical demands between the two competition
181 formats. Duration of each possession for the home and opposition team and the transition
182 time between possessions were used to calculate work-to-rest ratios. The total duration of
183 multiple possessions with a short transition phase (<30 sec) was determined as a “playing
184 period”. A time exceeding 30 seconds between possessions was defined as a “break period”.
185 Possessions with durations below eight seconds were defined as a “fast break”, indicating a
186 quick transitional style of play in offence. All data shown are standardized to 30 min playing
187 time (physical demands) or to 100 possessions (tactical demands).

188
189 <<Insert Table 1 here>>

190
191 *Statistical Analysis*

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

199
200 Inferential analyses were based on uncertainty in magnitudes of effects to overcome the
201 shortcomings associated with traditional statistical significance testing.²¹ Uncertainty in
202 effects is indicated with 99% confidence limits. Effects were deemed unclear if the
203 confidence interval overlapped the thresholds for smallest important increases and decreases
204 of counts or durations, which were assumed to be 10% (a factor of 1.10).²² Smallest
205 important changes for peak and mean heart rate values (expressed as percent of HRmax) were
206 0.5% and 1% for peak and mean heart rate respectively, which were approximately 0.2 x
207 between-subject standard deviation.²² Magnitudes of clear effects were described
208 probabilistically using the following scale: possibly 25-75%, likely 75-95%, very likely 95-
209 99.5%, and most likely >99.5%.²³

210

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%, $\pm 3.8\%$; mean, $\pm 99\%$ 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%, $\pm \sim 8\%$) 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 ($94 \pm 3\%$ of maximum heart rate; mean \pm SD) and tournament ($95 \pm 2\%$ of maximum heart rate) competition. There were possible differences in mean heart rate between the two competitions for total game time ($67.1 \pm 6.6\%$ vs. $68.1 \pm 5.8\%$ of maximum heart rate) or active playing time (84.3 ± 1.8 vs. $83.9 \pm 2.3\%$ of maximum heart rate). When comparing time spent in different heart rate zones, players likely spent 32% ($\pm 99\%$ confidence limits, $\pm 17\%$) more time in Zone 1 and possibly 7% ($\pm 12\%$) more time in Zone 4 in seasonal, but possibly 11% ($\pm 16\%$) more time in Zone 2 and 12% ($\pm 14\%$) 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, $\pm 1.8\%$) by the end of the tournament. The higher mean heart rate coincided with a likely 30% ($\pm 29\%$) increase in time spent in Zone 4 and a likely 21% ($\pm 17\%$) decrease in time spent in Zone 3 during the tournament.

260 *Tactical demands*

261 The mean duration of a possession in seasonal competition was 7% ($\pm 99\%$ confidence limits,
262 $\pm 9\%$) shorter than the tournament competition. The mean rest duration between possessions
263 was also 20% ($\pm 27\%$) shorter in seasonal than tournament competition. Accordingly, the
264 total number of possessions was 8% ($\pm 10\%$) higher in seasonal competition compared to
265 tournament competition. The higher number of possessions corresponds with 16% ($\pm 13\%$)
266 more fast breaks (possessions < 8 sec) in seasonal competition. The mean playing periods
267 were similar between seasonal and tournament competitions with no clear differences
268 between the two competitions. The mean break duration was 20% ($\pm 16\%$) longer in
269 tournament games than seasonal games. These mean playing and break durations reveal ~1.5
270 min of work, followed by 1 min of recovery throughout a basketball game.

271
272 Differences in the frequency of different offensive demands between seasonal and
273 tournament competition were largely unclear. Seasonal competition showed a substantially
274 higher number of ball reversals and dribble penetration. The frequency of hand-offs increased
275 substantially (47-50%, $\pm \sim 45\%$) during tournament and seasonal competition, whereas the
276 number of post entries substantially decreased over the season (71%, $\pm 35\%$). Ball reversals
277 and indirect screens occurred most frequently in both types of competition (Figure 3). The
278 duration of possessions (10%, $\pm 12\%$) and playing periods (62%, $\pm 48\%$) increased during the
279 tournament.

280
281 <<insert Table 2 here>>

282
283 **Discussion**

284
285 This is the first research project to compare differences and patterns in the physical,
286 physiological and tactical demands of seasonal and tournament competition in basketball.
287 Overall, seasonal games show a higher intensity in physical demands indicating a faster,
288 more stochastic game. Tournament competition entails fewer low intensity movement
289 patterns, but more high intensity movements as the competition progresses. The smaller
290 number of possessions in tournament games is consistent with observations that the
291 international tournament involved a more controlled offensive and defensive style of play.
292 The differing physical and tactical demands between seasonal and tournament competition
293 highlight the need for specific training programs of basketball players for the two competition
294 formats. Additionally, strategies limiting the effects of cumulative fatigue on movement
295 patterns in tournament competition need implementing.

296
297 The descriptive findings from this research extend previous reports on the physical and
298 physiological demands of male basketball competition. With 24-26 movements per min in
299 seasonal and tournament competition, the total number of movements (~1000) within a game
300 and the frequency of changes in movement every ~2 seconds are comparable to the
301 movement patterns reported in other male basketball games using standard time-motion
302 analysis.^{3,7} These results may underestimate the frequency in change in movement as a more
303 sensitive frame by frame time-motion analysis and additional movement categories revealed
304 ~twice the total movement frequencies.^{1,11} The higher frequency of high intensity movements
305 in seasonal games likely reflects the advantage of being fresh physically for each single game
306 with minimal cumulative fatigue effects from previous games. These physical demands in
307 seasonal competition indicate the need for basketball players and coaches to have a larger
308 focus on frequent high-intensity efforts in conditioning practices. Since repeat sprint ability is

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

330

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

343

344 Both seasonal and tournament competition show mean playing and break periods of ~1.5 and
345 1 min, respectively. These data indicate the need for basketball athletes to have the metabolic
346 capacity to be highly active for short periods of time (seconds to minutes) and then replenish
347 energy stores within a short rest period. Contemporary practice of Australian basketball
348 players involves conditioning towards three min periods (unpublished data). Our results
349 indicate a 1.5-2 min period may be more specific for basketball competition.

350

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

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

370

371

Practical Applications and Conclusions

372

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

386

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

394

Acknowledgments

396 The authors would like to acknowledge the staff and players of the 2011 Australian Emus
397 team and the AIS basketball program for support and participation in this research project.

398

References

399
400

- 401 1. Ben Abdelkrim N, Castagna C, Fazaa SE, Ati JE. The effect of players standard and tactical
402 strategy on game demands in men's basketball. *J Strength Cond Res.* 2010c;24(10):2652-
403 2662.
- 404 2. Ben Abdelkrim N, Castagna C, Jabri I, et al. Activity profile and physiological requirements
405 of junior elite basketball players in relation to aerobic-anaerobic fitness. *J Strength Cond Res.*
406 2010b;24(9):2330-2342.
- 407 3. Ben Abdelkrim N, Fazaa SE, Ati JE. Time-motion analysis and physiological data of elite
408 under-19-year-old basketball players during competition. *Br J Sports Med.* 2007;41:69-75.
- 409 4. Bishop DC, Wright C. A time-motion analysis of professional basketball to determine the
410 relationship between three activity profiles: high, medium and low intensity and the length of
411 the time spent on court. *Int J Perform Anal Sport.* 2006;6(1):130-139.
- 412 5. Janeira MA, Maia J. Game intensity in basketball. An interactionist view linking time-motion
413 analysis, lactate concentration and heart rate. *Coach Sport Sci J.* 1998;3(2):26-30.
- 414 6. Matthew D, Delextrat A. Heart rate, blood lactate concentration, and time-motion analysis of
415 female basketball players during competition. *J Sports Sci.* 2009;27(8):813-821.
- 416 7. McInnes S, Carlson J, Jones C, McKenna M. The physiological load imposed on basketball
417 players during competition. *J Sports Sci.* 1995;13:387-397.
- 418 8. Miller SA, Bartlett RM. Notational analysis of the physical demands of basketball. *J Sports*
419 *Sci.* 1994;12(2):181.
- 420 9. Narazaki K, Berg K, Stergiou N, Chen B. Physiological demands of competitive basketball.
421 *Scand J Med Sci Sports.* 2009;19(3):425-432.
- 422 10. Rodriguez-Alonso M, Fernandez-Garcia B, Perez-Landaluce J, Terrados N. Blood lactate and
423 heart rate during national and international women's basketball. *J Sports Med Phys Fitness.*
424 2003;43:432-436.
- 425 11. Scanlan AT, Dascombe BJ, Reaburn P. A comparison of the activity demands of elite and
426 sub-elite Australian men's basketball competition. *J Sports Sci.* 2011;29(11):1153-60.
- 427 12. Scanlan AT, Dascombe BJ, Reaburn P, Dalbo VJ. The physiological and activity demands
428 experienced by Australian female basketball players during competition. *J Sci Med Sport.*
429 2012;15(4):341-347.
- 430 13. Vaquera A, Refoyo I, Villa JG, et al. Heart rate response to game-play in professional
431 basketball players. *J Hum Sport Exerc.* 2008;3(1):1-9.
- 432 14. Ibanez SJ, Sampaio J, Saenz-Lopez P, Gimenez J, Janeira MA. Game statistics discriminating
433 the final outcome of junior world basketball championship matches (Portugal 1999). *J Hum*
434 *Mov Stud.* 2003;45:1-19.
- 435 15. Sampaio J, Lago C, Drinkwater EJ. Explanations for the United States of America's
436 dominance in basketball in the Beijing Olympic Games (2008). *J Sports Sci.* 2010;28(2):147-
437 152
- 438 16. Tsamourtzis E, Salonikidis K, Taxildaris K, Mawromatis G. Technisch-taktische Merkmale
439 von Siegern und Verlierern bei Herrenbasketballmannschaften. *Leistungssport.* 2002;1:54-58.
- 440 17. Tsamourtzis E, Karypidis A, Athanasiou N. Analysis of fast breaks in basketball. *Int J*
441 *Perform Anal Sport.* 2005;5(2):17-22.
- 442 18. Bazanov B, Vohandu P, Haljand R. Trends in offensive team activity in basketball.
443 *SPORTAS.* 2006;61(2):5-11.
- 444 19. Mavridis G, Tsamourtzis E, Karipidis A, Laios A. The inside game in World Basketball.
445 Comparison between European and NBA teams. *Int J Perform Anal Sport.* 2009;9:157-164.
- 446 20. Bangsbo J, Iaia F, Krstrup P. The Yo-Yo Intermittent Recovery Test : A useful tool for
447 evaluation of physical performance in intermittent sports. *Sports Med.* 2008;38(1):37-51.
- 448 21. Batterham AM, Hopkins WG. Making meaningful inferences about magnitudes. *Int J Sport*
449 *Phys & Perf.* 2006;1(1):50-57.

- 450 22. Hopkins WG. Linear models and effect magnitudes for research, clinical and practical
451 applications. *Sportscience*. 2010;14:49-57.
- 452 23. Hopkins WG, Marshall SW, Batterham AM, Hanin J. Progressive statistics for studies in
453 sports medicine and exercise science. *Med Sci Sports Exerc*. 2009;41(1):3-13.
- 454 24. Castagna C, Manzi V, D'ottavio S, et al. Relation between maximal aerobic power and the
455 ability to repeat sprints in young basketball players. *J Strength Cond Res*. 2007;21(4):1172-
456 1176.
- 457 25. Hoffman JR. The influence of aerobic capacity on anaerobic performance and recovery
458 indices in basketball players. *J Strength Cond Res*. 1999;13(4):407-411.
- 459 26. Montgomery PG, Pyne DB, Cox AJ, et al. Muscle damage, inflammation, and recovery
460 interventions during a 3-day basketball tournament. *Eur J Sport Sci*. 2008;8(5):241 - 250.
- 461 27. Delextrat A, Calleja-Gonzalez J, Hippocrate A, Clarke ND. Effects of sports massage and
462 intermittent cold-water immersion on recovery from matches by basketball players. *J Sports
463 Sci*. 2012;0(0):1-9.
- 464 28. Montgomery PG, Pyne DB, Hopkins WG, et al. The effect of recovery strategies on physical
465 performance and cumulative fatigue in competitive basketball. *J Sports Sci*.
466 2008;26(11):1135-1145.
- 467 29. Bosquet L, Merkari S, Arvisais D, Aubert AE. Is heart rate a convenient tool to monitor
468 overreaching? A systematic review of the literature. *Br J Sports Med*. 2008;42:709-714.

469

470

471

Figures & Tables

472
473
474
475
476
477

478
479
480

481

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.

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 |

^aCounts 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,

⁰possibly similar, ⁰⁰likely similar, ⁰⁰⁰very likely similar.