



LJMU Research Online

Malone, S, Solan, B, Collins, K and Doran, DA

The metabolic power and energetic demands of elite Gaelic football match play.

<http://researchonline.ljmu.ac.uk/3390/>

Article

Citation (please note it is advisable to refer to the publisher's version if you intend to cite from this work)

Malone, S, Solan, B, Collins, K and Doran, DA (2016) The metabolic power and energetic demands of elite Gaelic football match play. Journal of Sports Medicine and Physical Fitness. ISSN 1827-1928

LJMU has developed **LJMU Research Online** for users to access the research output of the University more effectively. Copyright © and Moral Rights for the papers on this site are retained by the individual authors and/or other copyright owners. Users may download and/or print one copy of any article(s) in LJMU Research Online to facilitate their private study or for non-commercial research. You may not engage in further distribution of the material or use it for any profit-making activities or any commercial gain.

The version presented here may differ from the published version or from the version of the record. Please see the repository URL above for details on accessing the published version and note that access may require a subscription.

For more information please contact researchonline@ljmu.ac.uk

<http://researchonline.ljmu.ac.uk/>

1 **Manuscript Title:** The metabolic power and energetic demands of Elite Gaelic football

2 match play

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

23 **Title:** The metabolic and estimated energetic demands of Elite Gaelic football match play

24 **Authors:** Shane Malone^{1,2}, Barry Solan², Kieran Collins², Dominic Doran^{1,2}

25

26 **Affiliations:**

27

28 ¹ The Tom Reilly Building, Research Institute for Sport and Exercise Sciences, Liverpool
29 John Moores University, Henry Cotton Campus, 15–21 Webster Street, Liverpool, L3 2ET

30

31 ² Gaelic Sports Research Centre, Department of Science, Institute of Technology Tallaght,
32 Tallaght, Dublin, Ireland.

33

34 Congress: N/A

35

36 Funding: N/A

37

38 Conflicts of Interest: N/A

39

40 **Acknowledgements:** The authors of the present study would like to thank all the teams who
41 participated during the research period. No external sources of funding were provided for
42 this study. The authors have no relevant conflicts of interest to declare.

43

44

45 **Corresponding author:** Shane Malone

46 The Tom Reilly Building, Research Institute for Sport and
47 Exercise Sciences, Liverpool John Moores University, Henry
48 Cotton Campus, 15–21 Webster Street, Liverpool, L3 2ET
49 United Kingdom

50 Email: shane.malone@mymail.ittdublin.ie

51

52

53

54

ABSTRACT

55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83

Aims: To compare the metabolic power demands between positional groups and examine the temporal profile of elite Gaelic football match play.

Design: Longitudinal observational study.

Methods: Global positional satellite system (GPS) data were collected from 50 elite Gaelic football players from 4 inter-county teams during 35 elite competitive matches over a three season period. A total of 351 complete match samples were obtained for final analysis. Players were categorised based on positional groups; full-back, half-back, midfield, half-forward and full-forward. Instantaneous raw velocity data was obtained from the GPS and exported to a customised spreadsheet which provided estimations of both speed based, derived metabolic power and energy expenditure variables (total distance, high speed distance, average metabolic power, high power distance and total energy expenditure).

Results: Match mean distance was 9222 ± 1588 m, reflective of an average metabolic power of $9.5\text{-}12.5 \text{ W}\cdot\text{kg}^{-1}$, with an average energy expenditure of $58\text{-}70 \text{ KJ}\cdot\text{kg}^{-1}$ depending on position. There were significant differences between positional groups for both speed-based and metabolic power indices. Midfielders covered more total and high-speed distance, as well as greater average and overall energy expenditure compared to other positions ($p < 0.001$). A reduction in total, high-speed, and high-power distance, as well as average metabolic power throughout the match ($p < 0.001$) was observed.

Conclusions: Positional differences exist for both metabolic power and traditional running based variables. The middle three positions (midfield, half-back and half-forward) possess greater activity profiles when compared to other positional groups. The reduction in metabolic power and traditional running based variables are comparable across match play. The current study demonstrates that metabolic power may contribute to our understanding of Gaelic football match-play.

Key Words: activity profile; match analysis; Gaelic football; energy demand; GPS.

INTRODUCTION

84

85 Gaelic football is a field sport where high-intensity actions are stochastic in nature
86 following the flow of competitive play ⁵. Match analysis of the game is becoming more
87 common with several studies having examined the physical activities of players with
88 particular reference to playing position ^{12, 18}, decrement in running performance across
89 halves¹⁸ and high intensity actions ⁵. These studies have typically used activity metrics such
90 as total distance, high speed running, sprint running, peak velocity and number of completed
91 accelerations. These actions have been shown in team sports to be influenced by contextual
92 factors such as opposition and team tactics ⁹. More recently accelerations have been reported
93 as an important determinant of Gaelic football competitive match demands ⁵; whether this
94 impacts on player performance and match success has yet to be empirically assessed. These
95 applied analyses have assisted in developing our understanding of the physical running
96 demands associated with competitive match-play within elite Gaelic football.

97 Recently reports from professional soccer ¹⁵, rugby league ¹¹ and Australian rules
98 football (AFL) ⁴ have shown that metabolic power can estimate power output and energetic
99 costs of intermittent running and competitive match play ^{4, 10, 11}. These investigations provide
100 an additional insight to previous studies which have employed traditional time motion
101 analyses of activity demands of training and match play ⁴. Analysis of training activity has
102 revealed a systematic bias for speed based metrics when compared to metabolic power based
103 metrics, with and underestimation of speed based metrics to quantify the true physiological
104 strain associated with match play ^{4, 10, 11} and training ⁸. These metabolic power calculations
105 are based on a theoretical model ¹³ which allows for the estimation of the energetic cost of
106 accelerations and decelerations during intermittent running and can be applied to a variety of
107 sports involving similar activity profiles ¹⁰.

108 While a number of limitations exist with the model in relation to the validity and
109 reliability ^{1, 19}, the model has been reported to provide energy cost estimates similar to
110 determined measures ¹⁰. Recently studies in soccer have reported very large correlations
111 between aerobic fitness variables and metabolic power estimates of high power distance
112 during professional soccer matches, providing evidence for concurrent validity to this novel
113 approach to indirectly assess the energetic cost of match play ¹⁵. The current model has been
114 applied directly to competitive AFL ⁴, rugby league ¹¹ and soccer ^{10, 15} in addition to training
115 analyses ⁸. These analyses have shown the model to be sensitive to decrements in running
116 performance during competition within AFL populations ⁴. In rugby league metabolic power
117 indices have been shown to be to stable to account for temporal fatigue changes in
118 performance ^{4, 11}.

119 To date no studies have investigated the metabolic power demands of elite Gaelic
120 football match-play, moreover no studies have used this method to analyse match related
121 fatigue and the energetic profile of competitive play. Therefore the aims of the current study
122 were to: 1) describe the metabolic demands of competitive elite Gaelic football match-play
123 for different positional groups; 2) compare the match activity profile information from
124 traditional speed zone methods to those derived from metabolic power calculations and 3)
125 examine the temporal profile in metabolic power indices during competitive match-play.

126

127

MATERIALS AND METHODS

128 Competitive game data were collected from 50 elite Gaelic football players (Age:
129 25.6 ± 2.9 years; mass 84.7 ± 8.8 kg; height: 185.4 ± 8.2 cm) from four inter county teams
130 across a four season period. A total of 355 player match files were obtained for analysis. The
131 mean (\pm SD) number of observations per player was 8.5 ± 6.4 (Range 5-23). Players were

132 categorised into the five distinct positional groups observed in Gaelic football: full-back (n =
133 64), half-back (n = 77), midfield (n = 71), half-forward (n = 79) and full-forward (n = 64)
134 with only full competitive game data included for final analysis. Informed consent and
135 institutional ethical approval were obtained before the commencement of the investigation.

136 Players movements were measured using global positioning satellite systems (GPS)
137 sampling at 4 Hz (VX Sport, Lower Hutt, New Zealand). The GPS device was encased within
138 a protective harness between the player's shoulder blades in the upper thoracic-spine region.
139 Before entering the field the GPS device was fixed to the athlete, the device was then
140 activated and satellite lock established for a minimum of 15 minutes before the
141 commencement of each match¹⁶. All players wore the same GPS unit for each match during
142 the seasons analysed to minimise inter-unit error^{6,7}. The validity and reliability of this device
143 has previously been communicated^{2,17}.

144 Game data was analysed post game with retrospective analysis conducted on all
145 games. Game data were downloaded using the same proprietary software (VXSport View;
146 Firmware 4.01.2.0). Each file was then trimmed so only data recorded during each full game
147 and specifically each quarter when the player was on the field was included for further
148 analysis. The proprietary software provided instantaneous raw velocity data at 0.25 s
149 intervals, which was then exported into a customised spreadsheet (Excel, Microsoft,
150 Redmond, USA). The spreadsheet allowed for calculation of distance covered in the
151 following speed categories; total distance; high speed running ($\geq 17 \text{ km}\cdot\text{h}^{-1}$, HSR) and sprint
152 distance ($\geq 22 \text{ km}\cdot\text{h}^{-1}$; SD). The metabolic power equation for estimation of instantaneous
153 energy cost and metabolic power were integrated into the spreadsheet and formed the bases
154 for all variable related to metabolic power analysis. The spreadsheet allowed for estimation of
155 average metabolic power ($\text{W}\cdot\text{kg}^{-1}$; P_{met}) and total energy expenditure ($\text{kJ}\cdot\text{kg}^{-1}$), as well as

156 distance (m) and energy produced above high power threshold ($>25 \text{ W}\cdot\text{kg}^{-1}$; HP).
157 Calculations were provided for equivalent distance (ED), which represents the equivalent
158 steady state distance required to match the estimated energy expenditure during exercise.
159 Additionally, the equivalent distance index (EDI) representing the ratio between ED and total
160 distance was calculated^{4, 10, 11}.

161 The assumptions of normality were verified prior to parametric statistical analysis.
162 Firstly a multivariate analysis of variance (MANOVA) was used to compare differences in
163 physical performance variables between positional groups (5) and playing quarter (4). If the
164 chances of a variable having higher and lower differences were $>5\%$, the true effect was
165 deemed to be unclear. Effect sizes (ES) were interpreted as <0.2 , trivial; 0.2-0.6, small; 0.6-
166 1.2, moderate; 1.2-2.0, large; >2.0 , very large differences in physical performance variables
167 between positional groups¹⁴. All data are reported as mean and 95% confidence intervals
168 unless otherwise stated.

169 RESULTS

170 Selected distance and metabolic power variables for each playing position are shown
171 in table 1. The MANOVA revealed significant main effects for playing position ($F = 14.8$, p
172 < 0.001). Post hoc analysis revealed that midfielders covered greater total distance compared
173 to all other positions (ES = 0.72-1.39). Similarly, midfielders also had higher relative
174 distances compared to all other positions (ES = 0.71-2.14), while higher values were
175 observed for half-backs and half-forwards compared to full-forwards (ES = 1.25) and full-
176 backs (ES = 1.06). Midfielders also had greater HSD compared to all other positions (ES =
177 0.80-2.37), while half-backs (ES = 1.04-1.65) and half-forwards (ES = 1.16-1.73) covered
178 more HSD than the other remaining position groups only. Half-forwards covered more SD
179 (ES = 0.55-4.08) and compared to all other positions, followed by half-backs (ES = 0.93-

180 2.83; 0.86-2.87) and midfielders (ES = 1.06- 2.74; 0.28-2.48), which recorded higher values
181 compared to the remaining position groups. In contrast, the highest P_{met} , energy expenditure
182 and equivalent distance was observed for midfield players (ES = 0.64-2.10; 0.52-1.39; 0.52-
183 1.39), followed by half backs (ES = 0.44-1.29; 0.44-1.36; 0.44-1.36) which were greater than
184 all other positions. The HP variables (i.e. distance, time and power) were greater for
185 midfielders (ES = 0.68-2.36; 0.87-2.16; 0.60-2.25) compared to all other positions, followed
186 by half-backs (ES = 1.00-1.68; 0.95-1.39; 1.00-1.68) and half-forwards (ES = 1.17-1.82;
187 0.89-1.26; 1.11-1.78), which were greater than all other positions except for midfielders.

188 Figure 1 shows temporal changes in selected distance and metabolic power variables
189 by playing quarter. The MANOVA revealed significant main effects for quarter ($F = 7.26$, p
190 < 0.001), with subsequent post hoc analyses revealing that the total distance and energy
191 expenditure in the second (ES=0.28; 0.29) and fourth (ES=0.45; 0.44) quarters were reduced
192 compared to the opening quarter only, while the fourth quarter distance was less than both the
193 first (ES = 0.54; 0.54) and second quarter (ES = 0.30; 0.30). There were reductions in HSD,
194 HP distance and P_{met} in the second (ES = 0.28; 0.30; 0.31) and fourth (ES = 0.36; 0.37; 0.37)
195 quarters when compared to the opening quarter, while the fourth quarter (ES = 0.31-0.65;
196 0.32-0.67; 0.25-0.60) values were lower than all other quarters. The EDI was lower in the
197 second quarter compared to the third quarter only (ES = 0.24).

198

199 ** Insert table 1 near here**

200

201

DISCUSSION

202 The current investigation implemented a novel approach for estimation of the
203 metabolic demands based on accelerated running to complement the traditional speed based

204 analysis of Gaelic football match-play. The study is the first to provide estimates of the
205 metabolic demands of elite Gaelic football match play. The main findings were that
206 traditional measures of running performance and metabolic power derived parameters
207 differed across positional groupings. In addition we found that high speed running distances
208 were most likely higher when compared to high power derived distances for the middle 3
209 positional groupings with external positioning groups showing very likely increases in high
210 power distance when compared to traditional analysis methods. Reductions in distance
211 travelled in speed zones and metabolic power measurements were observed across playing
212 quarters. In addition, the percentage differences between the two methods of running
213 performance analysis were shown to be position dependant (See table 1.)

214 In line with previous literature on team based field sports ^{4, 8, 10, 11, 18} positional
215 differences for both speed zone classifications including total, high speed and sprint distances
216 were identified. In addition to these positional variations similar trends were observed for
217 metabolic derived indices during competitive Gaelic football match play. Specifically,
218 midfielders covered a greater total distances and relative intensities ($\text{m} \cdot \text{min}^{-1}$) which was very
219 likely higher than all other positions. In addition, both high speed and sprint distances were
220 likely higher for midfielders, half-backs and half-forwards when compared to full-backs and
221 full-forwards. These results are comparable to previously reported during Gaelic football
222 match-play ^{5, 12}. The novel aspect of the current study is the analysis of metabolic power
223 derived indices during match-play, the data collected shows similar trends to traditional
224 running based variables with midfielders having greater P_{met} , total energy expenditure and
225 equivalent distance when compared to all other positions. Midfielders, half-forwards and
226 half-backs perform greater high power activities (i.e greater HP distance and power
227 production) compared to full-backs and full-forwards. These differences in activity profiles
228 may be explained by the specific tactical roles of each playing group e.g. the middle three

229 positions (half-back, midfield and half-forward) in Gaelic football typically have more
230 nomadic roles than other positions, this typically would allow for more space to complete
231 high power activities. Additionally these positional lines have more direct involvement in
232 play as their role is to win the ball and provide a transition of ball from defence to attack,
233 while full-back and full-forward lines are generally required to provide offensive pattern play
234 or a more direct defensive approach against an opposing full-forward.

235 ****Insert Figure 1 near here****

236 The metabolic power derived indices reported in the current study provide new
237 insights into the activity profiles of elite Gaelic football competition. The P_{met} for each
238 positional group ranged from 9.5-12.5 $W \cdot kg^{-1}$ which is higher than previously reported for
239 soccer training ⁸, rugby league match play ¹¹ and Australian rules match play ⁴ that have
240 utilised the same calculations as reported in this current analysis. Interestingly and similar to
241 data reported in AFL match play ⁴, the observed EDI was lower than that of soccer training ⁸
242 and rugby league ¹¹, suggesting a greater need for Gaelic players to be conditioned towards
243 continual running compared to accelerated running to meet running demands of match-play.
244 This observation is in contrast to soccer and rugby league demands where players run less
245 distance between acceleration and deceleration efforts. The current finding may be explained
246 by the greater field sizes observed in Gaelic football (33% larger) compared to soccer and
247 rugby league. The total energy expenditure ranged from 58-70 $Kj \cdot kg^{-1}$ which is slightly
248 higher than that reported for AFL match play and soccer match play respectively ^{4, 10}. The
249 energetic expenditure information provided in the current investigation may provide useful
250 data to nutritional practitioners to aid in pre- and post match nutritional intake, which can
251 assist in the optimisation of acute recovery techniques employed by elite Gaelic football
252 teams. Previous studies ³ have shown decreases in body composition (Body mass and %
253 Skinfold BF) across seasonal periods for Gaelic football players. Overall the current data will

254 further help practitioners aid in the maintenance of optimal body composition for Gaelic
255 football players throughout the competitive season through better understanding of match
256 play energetic demands.

257 Within soccer Gaudino et al.⁸ identified that depending on playing position HP
258 distance was between 62 and 84% greater than high speed running distances during training
259 games. As a result the authors cautioned that high speed running may neglect the contribution
260 of accelerated running and therefore underestimate the true energetic cost of training
261 activities. In contrast to this previous study, our results show a reduction in HP distance (2.2-
262 10.1% depending on position) when compared to high speed running during elite Gaelic
263 football match play. This is a finding that is in line with previous investigations within AFL⁴
264 while this was an unexpected finding several factors may explain this discrepancy. Firstly,
265 Gaelic football is a game played on a pitch that is approximately 33% larger than that of a
266 soccer pitch in addition during training games the pitch dimensions are largely compressed.
267 As a result of the above some running efforts in excess of the high speed threshold that occur
268 while accelerating and decelerating will not reach the HP threshold to the similar degree to
269 which they would during a compressed small sided training game. Similarly some running
270 efforts made by Gaelic football players can occur with little or no acceleration and thus
271 would not fall into the HP category of efforts. It is very possible that the structure of Gaelic
272 football provides more opportunities for running efforts that cross the high speed threshold
273 but not the HP thresholds due to both a larger pitch dimension and the absence of an offside
274 rule meaning more space for players. Indeed Gaudino et al.⁸ observed that the magnitude of
275 difference between speed zone and isopower methods was inversely related to the amount of
276 high speed activity completed in the training session.

277

278 The above findings may be explained by the large emphasis on continual running
279 bouts within elite Gaelic football match play, which therefore impacts the additional
280 contribution of HP distance to Gaelic football match analysis. From a practical perspective
281 the present results show that metabolic power estimates of HP distance provide little
282 additional insight when compared to traditional speed zone running distance variables. While
283 previous studies in Gaelic football have examined changes in running performance during
284 match-play⁵, this is the first study in Gaelic football to assess the temporal changes in
285 metabolic power variables during match-play. Our results show that P_{met} and HP distance
286 were reduced in the second and fourth quarters when compared to the first, while in the final
287 quarter all variables were reduced when compared to all other quarters of play. These
288 findings are similar to those found in the other team sports. Similar observations were seen
289 for energy expenditure, with lower values found in the second and fourth quarters of play.
290 There was no clear trend for EDI across the match with small reductions detected in the
291 second and fourth quarters of play. In the current study the observed reduction in metabolic
292 power derived variables were in line with similar changes seen in traditional speed zone
293 running metrics (i.e. total distance, HSR distance and SD) within this study. Collectively
294 these results show that metabolic power and traditional running based metrics may provide
295 similar trends during match play with metabolic power derived variables such as P_{met} , HP
296 distance and energy expenditure appearing to be sensitive to fatigue related reductions in
297 competitive play however these variables follow similar trends seen in total distance, high
298 speed distance and sprint distance.

299 While the current analysis is novel and metabolic power potentially can offer
300 important contributions to further our understanding of demands within team sports such as
301 Gaelic football, it is essential to consider the assumptions and limitations of the original
302 theoretical model proposed by di Prampero et al.¹⁰. These relate to the location of the centre

303 of mass of the body and the influence of limb movement on running energetic, the validity of
304 the equation for assessing high equivalent slopes and the influence of air resistance.
305 Additionally the model fails to consider eccentric work and how this influences energetic
306 kinetics during locomotion, while these movements are known to have a low impact on
307 energetic cost they can contribute significantly to muscular fatigue ⁴. A further limitation
308 which is common to all forms of locomotion analysis is that game specific actions such as
309 collisions, tackling, kicking and jumping are not accounted for. Additionally post exercise
310 bout energetic cost (excess post-exercise O₂ consumption) is not accounted for by GPS
311 technology as the method utilised player movement as a reference for energetic cost, in
312 contrast, human energetic cost can occur without locomotion ¹. Accordingly, the estimates
313 provided in the current study neglect the contribution of these actions to overall energy
314 expenditure.

315 CONCLUSION

316 The current investigation examined the metabolic power demands of elite Gaelic
317 football match play in conjunction with traditional speed derived running variables. The main
318 findings were that positional differences exist for both metabolic power and traditional
319 running. In general midfielders, half-backs and half-forwards had the greater activity profiles
320 when compared to other positional groups. In addition both metabolic power and traditional
321 running metrics followed similar temporal trends across match play. Finally, the HP distance
322 was less across all positional groups when compared to HSR distance, which may be
323 explained by the elevated HSR demands of elite Gaelic football. The study shows that
324 metabolic power data may contribute to our knowledge of the physical demands of Gaelic
325 football competition through providing estimates of energetic expenditure across match play.

326

327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348

PRACTICAL APPLICATION

- ❖ Traditional speed derived running indices such as high speed running are appropriate for analysing match activities during elite Gaelic football match play.
- ❖ Instantaneous acceleration derived energetic and metabolic power measures provide a novel approach for estimation of training and match-play loads, whether these measures provide additional useful information to traditional running based indices is questionable as they follow similar trends.
- ❖ The estimated energetic and metabolic power demands of Gaelic football have been identified for the first time for coaches. The demands allow coaches to create training situations that best replicate these demands for players based on their specific positional requirements.
- ❖ Estimations of energy expenditure during match-play may provide useful information to nutritional experts for energy replacement requirements post training and competitive play.

349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371

REFERENCES

1. Buchheit M, Manouvrier C, Cassirame, Morin JB. Monitoring locomotor load in soccer: Is metabolic power, powerful? *Int J Sports Med* 2015; 36(14): 1149-1155. doi: 10.155/s-0035-15552927
2. Buchheit M, Allen A, Poon, TK, Modonutti M, Gregson W, Di Salvo V. Integrating different tracking systems in football: multiple camera semi-automatic system, local positioning measurement and GPS technologies. *J Sports Sci* 2014; 32(20):1844-1857
3. Beasley KJ. Nutrition and Gaelic football: Review, recommendations and future considerations. *Int J Sport Nutr Exerc Metab* 2015; 25(1):1-13.
4. Coutts AJ, Kempton T, Sullivan C, Bilsborough J, Cordy J, Rampinini E. Metabolic power and energetic costs of professional Australian football match play. *J Sci Med Sport* 2015; 18(2):219-224.
5. Collins DK, Solan B, Doran, DA. A preliminary investigation into high-intensity activity during elite Gaelic football. *J Sports Therapy* 2013;1: 10.
6. Duffield R, Reid M, Baker J, Spratford W. Accuracy and reliability of GPS devices for measurement of movement patterns in confined spaces for court-based sports. *J Sci Med Sport* 2009; 13(5):523-525.

- 372 7. Jennings D, Cormack S, Coutts AJ, Boyd LJ, Aughey RJ. Variability of GPS units
373 for measuring distance in team sport movements. *Int J Sports Physiol Perform* 2010;
374 5(4):565–569
375
- 376 8. Gaudino P, Iaia FM, Alberti G, Strudwick AJ, Atkinson G, Gregson W. Monitoring
377 training in elite soccer players: systematic bias between running speed and metabolic
378 power data. *Int J Sports Med* 2013; 34(11):963-968.
379
- 380 9. Paul DJ, Bradley PS, Nasis G. Factor affecting running performance in elite soccer
381 players: Shedding some light on the complexity. *Int J Sports Physiol Perform* 2015;
382 10:516–519.
383
- 384 10. Osgnach C, Poser S, Bernardini R, Rinaldo R, di Prampero PE. Energy cost and
385 metabolic power in elite soccer: a new match analysis approach. *Med Sci Sports
386 Exerc* 2010; 42(1):170-178.
387
- 388 11. Kempton T, Sirotic AC, Coutts, AJ. Metabolic power demands of rugby league match
389 play. *Int J Sports Physiol Perform*; 2015; 10(1):23-28
390
- 391 12. Keane S, Reilly T, Hughes M. Analysis of work-rates in Gaelic football. *Aus J Sci
392 Med Sport*. 1993; 25(4): 100-102.
393
- 394 13. di Prampero P, Fusi S, Sepulcri L, Morin JB, Belli A, Antonutto G. Sprint running: a
395 new energetic approach. *J Exp Biol* 2005; 208(14):2809-2816.
396

- 397 14. Hopkins W, Marshall S, Batterham A, Hanin J. Progressive statistics for studies in
398 sports medicine and exercise science. *Med Sci Sports Exerc* 2009; 41(1):3-13.
399
- 400 15. Manzi V, Impellizzeri FM, Castagna C. Aerobic fitness ecological validity in elite
401 soccer players: a metabolic-power approach. *J Strength Cond Res* 2013; 28(4):914-
402 919.
403
- 404 16. Maddison R, Ni Mhurchu C. Global positioning system: A new opportunity in
405 physical activity measurement. *Int J Beh Nutr Phys Activ* 2009; 6: 73.
406
- 407 17. Malone S, Doran DA, Collins DK, Morton J, McRobert AP. Accuracy and reliability
408 of VXsport global positioning system in intermittent activity. In: Proceedings of the
409 19th Annual Congress of the European College of Sport Science, 2-5th July,
410 Amsterdam, 2014. Abstract: doi: 10.13140/RG.2.1.1559.6245.
411
- 412 18. Malone S, Solan B, Collins DK, Doran DA. The positional match running
413 performance of elite Gaelic football. *J Strength Cond Res* 2015; Dec 18. [Epub ahead
414 of print] doi: 10.1519/JSC.0000000000001309.
415
- 416 19. Stevens TG, De Ruiter CJ, Van Maurik D, Van Lierop CJ, Savelsbergh GJ, Beek PJ.
417 Measured and estimated energy cost of constant and shuttle running in soccer players.
418 *Med Sci Sports Exerc* 2015; 47: 1219-1224
419
420

421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440

TITLES OF TABLES

Table 1 - Match distance and metabolic power variables by playing position (Mean \pm 95% CI)

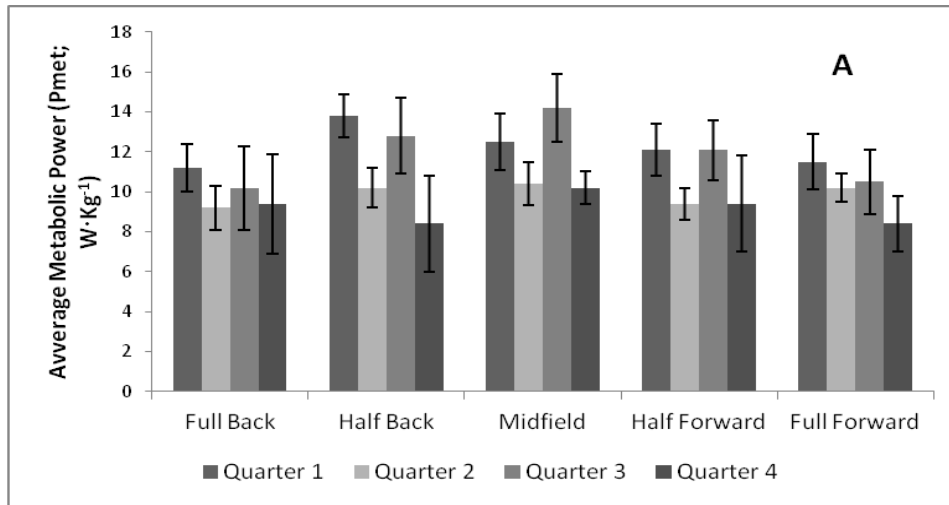
TITLES OF FIGURES

Figure 1 – Selected metabolic power variables shown across quarters of match play.
A. Average Metabolic Power (P_{met} ; $W \cdot Kg^{-1}$); B. Energy Expenditure ($kJ \cdot Kg^{-1}$); C. High Power Distance (m); D. Equivalent Distance Index

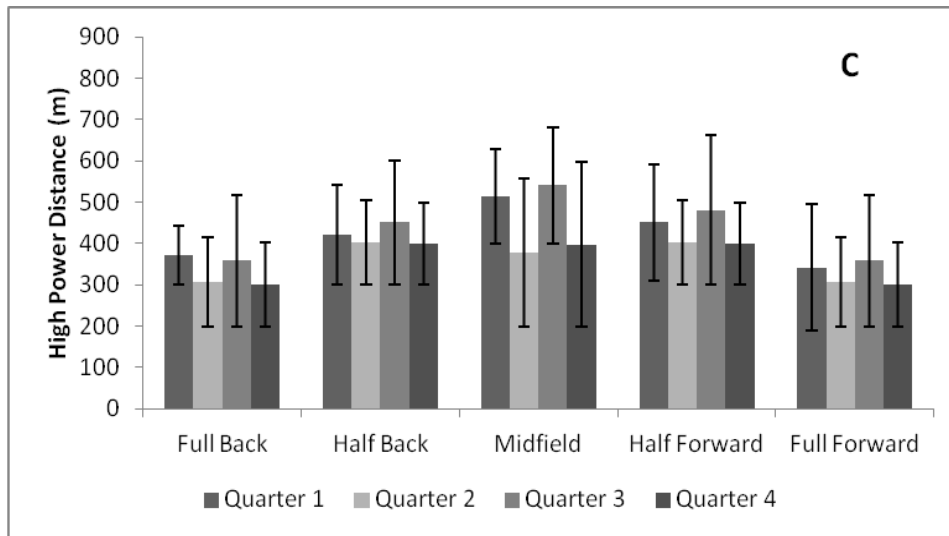
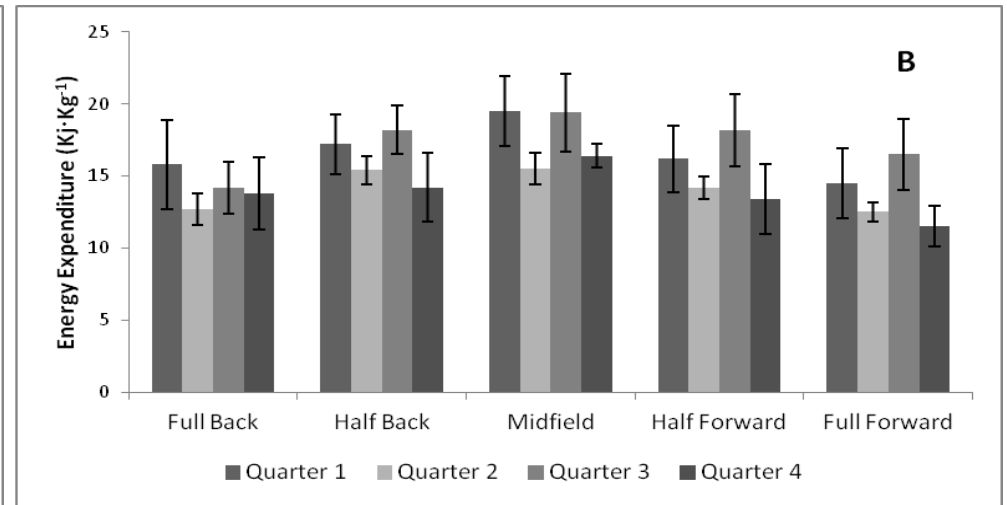
441 **TABLE 1.**

	Full-Back (n = 64)	Half-Back (n = 77)	Midfield (n = 71)	Half-Forward (n = 79)	Full-Forward (n = 64)
Distance Variables					
Total Distance (m)	7878 (7437-7920) ^{abc}	9621 (9341 - 9899) ^{ade}	10621 (10621-11114) ^{cde}	10121 (9941 - 10214) ^{ade}	7870 (7579 – 7974) ^{abc}
High Speed Distance (m) ($\geq 17 \text{ km}\cdot\text{h}^{-1}$)	1331 (1289-1598) ^{abc}	1831 (1821 - 2011) ^{ade}	2021 (1981 - 2562) ^{cde}	1851 (1824 - 2111) ^{ade}	1351 (1284 - 1441) ^{abc}
Sprint Distance (m) ($\geq 22 \text{ km}\cdot\text{h}^{-1}$)	381 (371-391) ^{abcd}	478 (446 - 498) ^{de}	458 (438 - 481) ^{ef}	488 (486 - 501) ^{ade}	357 (350 - 364) ^{abc}
Accelerations (n)	165 (146-175) ^{abc}	204 (184 - 218) ^{acde}	214 (198 - 245) ^{bcde}	196 (165 - 198) ^{ade}	152 (144 - 165) ^{abc}
Relative Distance ($\text{m}\cdot\text{min}^{-1}$)	112 (107-116) ^{abc}	137 (131 - 140) ^{acde}	151 (141 - 161) ^{bcde}	144 (137 - 154) ^{ade}	112 (108 - 118) ^{abc}
Metabolic Power Variables					
Average metabolic power (P_{met}) ($\text{W}\cdot\text{Kg}^{-1}$)	10.2 (9.9 - 10.6) ^{abc}	11.8 (11.1 - 12.1) ^{de}	12.5 (12.2 - 12.7) ^{bde}	11.1 (10.9 - 11.4) ^{de}	9.5 (9.2 - 9.7) ^{abc}
Energy Expenditure ($\text{kJ}\cdot\text{Kg}^{-1}$)	59.2 (57.1 - 61.2) ^{abc}	65.1 (63.1 - 67.5) ^{de}	70.2 (69.1 - 75.1) ^{bde}	64.8 (63.4 - 66.4) ^{de}	58.1 (56.1 - 60.2) ^{abc}
Equivalent Distance (m)	8697 (8574 - 8799) ^{abc}	10660 (10584 - 10768) ^{ade}	11800 (11674 - 11915) ^{bde}	11113 (11087 - 11214) ^{de}	8688 (8488 - 8947) ^{abc}
Low Power Distance (m) ($<25 \text{ W}\cdot\text{kg}^{-1}$)	7396 (7084 - 7695) ^{abc}	8928 (8724 - 9021) ^{de}	9984 (9784 - 10251) ^{bde}	9381 (9281 - 9541) ^{de}	7359 (7259 - 7458) ^{abc}
High Power Distance (m) ($>25 \text{ W}\cdot\text{kg}^{-1}$)	1301 (1001-1502) ^{abc}	1732 (1532 - 1951) ^{ade}	1816 (1745 - 1958) ^{bde}	1732 (1532 - 1874) ^{de}	1309 (1109 - 1541) ^{abc}
Comparisons					
Equivalent vs Total (%)	10.4 (10.2 – 10.6) ^{ab}	10.8 (10.2 – 11.1) ^b	11.1 (10.8 – 11.3) ^{bcde}	9.8 (9.4 – 10.2) ^{de}	10.4 (9.8 – 10.6) ^{ac}
High Power Distance vs High Speed Distance (%)	-2.2 (-3.2 – 1.1) ^{abc}	-5.4 (-5.1 – 1.1) ^{de}	-10.1 (-8.1 - -10.3) ^{bcde}	-6.4 (-6.2 - - 6.6) ^{de}	-3.1 (-2.8 – 1.2) ^{abc}
442	Significantly different from a Midfielders, b Half-Forwards, c Half-Backs, d Full-Forwards, e Full-Backs (all $p < 0.001$)				
443					
444					

445 **FIGURE 1.**



446



447

