

1 Elite male Flat jockeys display lower bone density and lower resting metabolic rate
2 than their female counterparts: Implications for athlete-welfare

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5 **Abstract:**

6 To test the hypothesis that daily weight-making is more problematic to health in male
7 compared with female jockeys, we compared the bone-density and resting metabolic
8 rate (RMR) in weight-matched male and female Flat-jockeys. RMR ($\text{kcal}\cdot\text{kg}^{-1}$ lean
9 mass) was lower in males compared with females as well as lower bone-density Z-
10 scores at the hip and lumbar spine. Data suggest the lifestyle of male jockeys'
11 compromise health more severely than females, possibly due to making-weight more
12 frequently.

13

14 **Keywords:** Jockey, weight-making, metabolism, bone, hydration, injury

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16

17 **Introduction:**

18 Professional jockeys are unique amongst weight-making athletes in so much as they
19 are required to make-weight all-year round and on a daily basis (Wilson et al. 2014).
20 It has been widely reported that in order make-weight jockeys will engage in
21 unhealthy weight-loss practices such as food deprivation and dehydration
22 (Labadarios et al. 1993; Leydon and Wall 2002; Moore et al. 2002; Warrington et al.
23 2009; Wilson et al. 2013a; Wilson et al. 2015), chronic fluid restriction (Leydon and
24 Wall 2002; Dolan et al. 2011; Wilson et al. 2013b) and self-induced vomiting (Moore
25 et al. 2002; Dolan et al. 2011). Such practices compromise markers of health and
26 well-being particularly relating to bone (Warrington et al. 2009; Waldron-Lynch et al.
27 2010; Dolan et al. 2012; Wilson et al. 2013a; Wilson et al. 2015) and mood (Leydon
28 and Wall 2002; Caulfield and Karageorghis 2008; Wilson et al. 2012b; Wilson et al.
29 2013a) Additionally, it has been reported that rapid weight-loss in jockeys
30 compromises their physical strength and riding performance (Wilson et al. 2013b),
31 which may increase the occupational hazards of race-riding (Dolan et al. 2013;
32 Wilson et al. 2013b).

33 Whereas, previous literature on weight-making and jockey health has by-and-large
34 concentrated on male professional jockeys, there exists little data on female
35 professional jockeys although they too are required to make-weight on a daily basis.
36 We therefore recruited male and female weight-matched professional jockeys to
37 examine effects of daily weight-making on markers of bone health and resting
38 metabolic rate. Given the requirement of males and females to ride at the same
39 weight despite known gender differences in lean body mass we hypothesised that
40 the adverse health consequences observed to date in professional jockeys would be

41 significantly worse in male compared with female jockeys, because of the known
42 gender differences in lean body mass (Buchholz et al. 2001).

43 **Materials and methods:**

44 Sixteen (n=8 male; n=8 female) professional Flat jockeys volunteered for this study
45 (the subject characteristics can be seen in Table 1). At the time of the study, all
46 jockeys were currently race-riding in Great Britain (GB) and therefore were actively
47 making-weight on a daily basis. Jockeys reported to the laboratory at ~ 9.30am,
48 following an overnight fast for the assessment of hydration status, bone density,
49 body composition and resting metabolic rate (RMR). For the most recent year (2014)
50 the male group had an average of 368 (\pm 198) professional race-rides and females
51 had 162 (\pm 123) (Post 2015). Both groups were free of injury at the time of testing
52 and none of the jockeys were smokers, taking medication or nutritional supplements.
53 Jockeys provided a mid-flow urine sample for assessment of osmolality using a
54 handheld refractometer (Atago, USA) which has previously been validated against
55 freezing point depression (Sparks and Close 2013). Jockeys were then measured in
56 minimal clothing (vest and shorts) for height and weight on a dual height/weight
57 stadiometer (Seca, Germany), before having whole body composition and hip and
58 lumbar bone sites analysed using dual-energy X-ray absorptiometry (DXA) scan
59 (Hologic, USA). Finally, jockeys then underwent a 20-min assessment of resting
60 metabolic rate (RMR) in a supine position using indirect calorimetry (Melayser, USA).
61 Resting metabolic rate was calculated by the averaged breath-by-breath VO_2 .
62 ($\text{L}\cdot\text{min}^{-1}$) from the last 15-min of the 20-min collection period (Compher et al. 2006)
63 and multiplied by 60 (representing minutes) and 24 (representing hours), and by the
64 calorific value corresponding to the averaged respiratory quotient value in the Table
65 of Zuntz (Zuntz 1901). All testing took place in the same building with RMR taking

66 place after the DXA scan in an adjacent room to the main laboratory. The jockeys
67 were supine for an additional 15 minutes prior to the commencement of the RMR
68 examination to allow the effects of movement to dissipate.

69 **Statistical analysis:**

70 All data were analysed using SPSS for Windows (Version 22 SPSS Inc. USA). Data
71 were initially checked for normality and then independent T-tests were performed to
72 compare male with female jockeys. All data were reported as means (\pm SD) with
73 additionally 95% confidence intervals (CI), and statistical significance was set at
74 $P \leq 0.05$.

75

76 **Results:**

77 All data are presented in Table 1. There were no significant difference in total body
78 mass ($P=0.78$; 57 ± 2.1 vs. 57.3 ± 3.5 kg) or height ($P=0.07$; $167 (\pm 4)$ vs. 163 ± 5)
79 between males and females respectively. Despite greater lean body mass ($P=0.01$;
80 5.7 ± 1.2 vs. 4.2 ± 3.3 kg) and lower percentage body fat ($P=0.01$; 12.5 ± 2.7 vs. 19.5
81 ± 2.5 %) in males compared with females, respectively, no differences in RMR were
82 apparent ($P=0.59$; 1484 ± 141 vs. 1540 ± 110 kcal.day⁻¹). However, there was a
83 significant difference in RMR when expressed as kcal.kg⁻¹ lean mass ($P=0.01$; 33 ± 3
84 vs. 36 ± 2) in males compared with females respectively. Males had lower bone
85 mineral density (BMD) Z scores at the hip ($P=0.03$; -1.2 ± 1.0 vs. -0.02 ± 0.8) and
86 lumbar spine ($P=0.02$; -1.6 ± 1.3 vs. -0.3 ± 0.8) compared with females. There was
87 no significant difference in BMD in g.cm² at the hip ($P=0.21$; 0.89 ± 0.1 vs. $0.87 \pm$
88 0.15) although there was a trend for a significant difference at the lumbar spine
89 ($P=0.09$; 0.90 ± 0.14 vs. 1.02 ± 0.13) for males versus females respectively. Morning

90 urine osmolality was significantly greater ($P=0.05$; 773 ± 257 vs 432 ± 231
91 $\text{mOsmol}\cdot\text{L}^{-1}$) as was the total number of rides in the 2014 season ($P=0.01$; 368 ± 198
92 vs. 162 ± 123 rides) in males compared with females.

93 **Discussion:**

94 The main aim of the present study was to compare the RMR and bone density of
95 weight-matched adult elite male and female professional Flat jockeys to test the
96 hypothesis that daily weight-making is more problematic to health in male compared
97 with female jockeys. We report for the first time that despite the male jockeys
98 demonstrating significantly greater lean muscle mass, there was no difference in
99 absolute RMR, which is in contrast to that seen in healthy active people (Arciero et al.
100 1993; Buchholz et al. 2001). Importantly, when RMR was expressed relative to lean
101 mass, females had a significantly greater RMR. Moreover, female jockeys had
102 significantly higher bone density Z and T scores at the hip and lumbar spine as well
103 as a trend for higher BMD ($\text{g}\cdot\text{cm}^2$) at the lumbar spine. These data confirm the
104 hypothesis that RMR and bone density of male jockeys are compromised compared
105 to their female counterparts that may be due to reduced lean mass making weight-
106 making easier, and/or the fact that the female jockeys have less race-rides in a given
107 season.

108

109 Our data concur with previous research that professional male jockeys have sub-
110 optimal bone health (Leydon and Wall 2002; Warrington et al. 2009; Waldron-Lynch
111 et al. 2010; Dolan et al. 2012; Wilson et al. 2013a). A likely explanation is that male
112 jockeys have inadequate energy availability (Wilson et al. 2014) for normal
113 physiological function (Loucks 2004), given energy availability has been reported as

114 low as ~ 19 kcal kg⁻¹ lean mass (Wilson et al. 2013a), that is considerably lower than
115 the consensus value 45 kcal kg⁻¹ lean mass (Loucks et al. 2011). Interestingly,
116 despite having to ride at the same weight the BMD of the female jockeys did not
117 present as problematic using the International Society for Clinical Densitometry
118 (ISCD) guidelines.

119

120 In the one previous study to measure bone density of senior female jockeys using
121 DXA (Leydon and Wall 2002) it was reported that 2 of the senior female cohort (n=5)
122 were classed as having osteopenia (T-score < -1 at two sites), which did not apply to
123 any of the 8 female jockeys in our study. Whereas the female jockeys in the present
124 study displayed lower bone density in comparison with other female weight-making
125 athletes (Trutchnigg et al. 2008), their bone density Z and T-scores were
126 significantly higher at both sites compared with the males. Previous work on the
127 bone density of female weight-making athletes from other sports appears limited to
128 one study on female boxers, who demonstrated that the boxers had greater bone
129 density compared with physically active female non-boxers (Trutchnigg et al. 2008).
130 Taken together these data suggest it is not weight-making *per se* that is the driver of
131 reduced bone density in jockeys but rather a combination of weight-making and
132 limited weight-bearing activity, combined with being required to make-weight daily. It
133 is possible that the greater bone density in female compared with male jockeys in
134 this study could be due to females possessing lower lean mass and being shorter in
135 stature resulting in a reduced need for these jockeys to engage in severe weight-
136 making regimes such as food deprivation and sweating (Dolan et al. 2011; Wilson et
137 al. 2013b). This suggestion is supported by the fact that the urine osmolality data
138 suggested that male jockeys in this study were dehydrated, whereas female jockeys

139 presented euhydrated (Shirreffs and Maughan 1998). Moreover, it was observed that
140 the females competed in significantly less race-rides than the male jockeys thus
141 subjecting them to less frequent weight-making days. Although the precise reason
142 for the poorer bone density in the male jockeys is unclear this study suggests that
143 specific guidance should be given to the male jockeys in regards to strategies to
144 improve bone health although weight-making advice for both groups are still clearly
145 required.

146

147 Of particular interest was the lack of significant difference in RMR between the two
148 genders. This observation is in direct contrast with data from non-weight- making
149 athletic groups (Thompson et al. 1996) and healthy active subjects (Arciero et al.
150 1993; Buchholz et al. 2001) that have all consistently reported greater RMR in males
151 compared with females. It should however be stressed that to the authors knowledge
152 this is the first data to compare RMR between males and female athletes engaged in
153 a weight-making sport. Given that lean body mass is widely accepted as the single
154 predictor variable for assessing RMR (Cunningham 1980) the observation that there
155 was no difference in RMR despite significantly greater lean body mass in the males
156 was somewhat unexpected. Although the present study was not designed to answer
157 this question we postulate that this could be due to more severe weight-making
158 practices employed by male jockeys including food deprivation and fasting to make-
159 weight (Labadarios et al. 1993; Moore et al. 2002; Dolan et al. 2011; Wilson et al.
160 2013b), despite recent data from our laboratory suggesting that such practices are
161 unnecessary (Wilson et al. 2012a; Wilson et al. 2015). Indeed, we have recently
162 demonstrated that by increasing food frequency, adding structured exercise and
163 changing the macronutrient composition, the RMR in 10 professional jockeys

164 significantly increased whilst the jockeys concomitantly reduced their body fat
165 (Wilson et al. 2015).

166 In conclusion, the male elite professional Flat jockeys in this study demonstrated
167 reduced bone density and a compromised RMR compared with female jockeys,
168 which is likely due to greater stresses of making-weight. The reduced bone density in
169 the male jockeys increase the risk of injury in the event of a fall. It appears that male
170 jockeys particularly require alternatives to food deprivation and fasting, as a tool to
171 make-weight, such as those demonstrated previously by our group (Wilson et al.
172 2012a; Wilson et al. 2015) and further highlights the need for targeted education in
173 these athletes.

174

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