Markers of Bone Health, Bone-Specific Physical Activities, Nutritional Intake, and Quality of Life of Professional Jockeys in Hong Kong

Eric Tsz-Chun Poon, John O’Reilly, Sinead Sheridan, Michelle Mingjing Cai, and Stephen Heung-Sang Wong
The Chinese University of Hong Kong

Weight-making practices, regularly engaged in by horse racing jockeys, have been suggested to impair both physiological and mental health. This study aimed to assess bone health markers, nutritional intake, bone-specific physical activity (PA) habits, and quality of life of professional jockeys in Hong Kong (n = 14), with gender-, age-, and body mass index-matched controls (n = 14). Anthropometric measurements, serum hormonal biomarkers, bone mineral density, bone-specific PA habits, nutritional intake, and quality of life were assessed in all participants. The jockey group displayed significantly lower bone mineral density at both calcanei than the control group (left: 0.50 ± 0.06 vs. 0.63 ± 0.07 g/cm²; right: 0.51 ± 0.07 vs. 0.64 ± 0.10 g/cm², both p < .01). Thirteen of the 14 jockeys (93%) showed either osteopenia or osteoporosis in at least one of their calcanei. No significant difference in bone mineral density was detected for either forearm between the groups. The current bone-specific PA questionnaire score was lower in the jockey group than the control group (5.61 ± 1.82 vs. 8.27 ± 2.91, p < .05). Daily energy intake was lower in the jockeys than the controls (1,360 ± 515 vs. 1,985 ± 1,046 kcal/day, p < .01). No significant group difference was found for micronutrient intake assessed by the bone-specific food frequency questionnaire, blood hormonal markers, and quality of life scores. Our results revealed suboptimal bone conditions at calcanei and insufficient energy intake and bone-loading PAs among professional jockeys in Hong Kong compared with healthy age-, gender-, and body mass index-matched controls. Further research is warranted to examine the effect of improved bone-loading PAs and nutritional habits on the musculoskeletal health of professional jockeys.

Keywords: bone mineral density, horse racing jockeys, nutrition, physical activity habits, weight making

Horse racing is one of the most popular sports worldwide and generates billions of dollars in revenue from both the breeding industry and gambling (Wilson et al., 2014a). In Hong Kong, there are more than 600 races each year (Hong Kong Jockey Club, 2015), and three of the world’s best 11 horses (as per the Longines™ World’s Best Racehorse Rankings 2015) are trained in the city. As horse racing is classified as a weight-category sport, most competitions require jockeys to align their body mass within certain race limits. For example, the current minimum weight allocation for jockeys in Hong Kong is 51.3 kg (Hong Kong Jockey Club, 2016). Professional jockeys are unique among weight-category athletes in that they are required to be weighed immediately before and after every race, which can be up to 10 times on a typical race day during their prolonged competitive season. Hence, they may have insufficient time to replenish energy and fluid depleted during weight making (Dolan et al., 2012a; Wilson et al., 2014a). Consequently, use of potentially dangerous acute and chronic weight-making strategies, including extreme calorie restriction, sporadic eating, self-induced vomiting soon after consumption, laxative use, sweating in saunas and hot baths, and excessive exercise in sweat suits have been reported among jockeys (Cotugna et al., 2011; Dolan et al., 2011; Labadarios et al., 1993; Leydon & Wall, 2002; O’Reilly et al., 2016; Wilson et al., 2014b). A recent study conducted in professional jockeys in Hong Kong found that fatigue (27.7%) was the most common side effect of weight loss followed by dehydration (22.3%) and headache (20%; O’Reilly et al., 2016). Such weight-making strategies are suggested to be harmful for psychological (Caulfield & Karageorghis, 2008); physiological (Warrington et al., 2009); and hormonal function (Dolan et al., 2012b). Moreover, jockeys are positioned in a continuous state of dynamic imbalance approximately 2–3 m from the ground, moving at a speed often up to 60 km/hr during racing (Warrington et al., 2009). Given the occupational safety concern that high-speed falls and bone fractures are frequent (Rueda et al., 2010), achieving optimal bone health is of paramount importance for jockeys. However, previous research suggested that extreme dietary weight-making practices can result in an inadequate intake of macronutrients and micronutrients such as calcium and vitamin D, consequently leading to bone-specific clinical conditions, including osteopenia and osteoporosis (O’Reilly et al., 2016; Warrington et al., 2009). Recently, osteopenia characterized by a bone mineral density (BMD) T score between −1 and −2.5 in the lower limb was reported in Hong Kong jockeys (O’Reilly et al., 2016), whereas earlier studies in New Zealand (Leydon & Wall, 2002) and Ireland (Dolan et al., 2012a; Warrington et al., 2009) have also found suboptimal bone health among elite-level jockeys, as demonstrated by a BMD T score < −1, indicating either osteopenia or osteoporosis of whole body, lumbar spine, and hip.

Poon, O’Reilly, Sheridan, Cai, and Wong are with the Dept. of Sports Science and Physical Education, The Chinese University of Hong Kong, Shatin, Hong Kong. Address author correspondence to Stephen Heung-Sang Wong at hsswong@cuhk.edu.hk.
In addition to dietary influence, the lack of bone-specific (i.e., weight bearing) exercise has also been suggested to play a role in precipitating osteogenic problems among jockeys (Alfredson et al., 1998; Cullen et al., 2009; Dolan et al., 2012a). High-impact activities such as jumping, plyometric exercise, or high-intensity weightlifting have been well documented to improve bone health outcomes across the age spectrum (Kohrt et al., 2004). A previous study (Dolan et al., 2012a) compared the bone health of male jockeys with that of boxers, who also engage in weight-making practices regularly. The authors concluded that the superior bone health observed in the boxer group may be attributed to their routine weight-bearing exercise to increase power and speed, which stimulates bone growth. On the other hand, another study (Cullen et al., 2009) evaluated the loading nature of horse racing by comparing the forces placed on the lower limbs of jockeys during riding (walk, trot, canter, gallop) and traditional weight-bearing activities, including walking and running. Lower-limb accelerations during walking on legs were found to be similar to trotting and significantly lower to walking on a horse, whereas running resulted in much greater lower-limb force impact on jockeys than all riding gaits. Such findings indicate the relatively low loading nature of horse racing. To date, however, limited research has used validated instruments to quantify the overall bone-specific loading nature of various physical activities (PAs) among jockeys.

Recent studies examining bone health in jockeys have also assessed endocrine function. It is hypothesized that suboptimal bone density is attributed to the disruption of endocrine profiles involved in growth and repair (Dolan et al., 2012b). Key hormones related to bone metabolism, such as testosterone, cortisol, and vitamin D, may be downregulated at times of low energy availability to allow the body to conserve energy for essential processes (Dolan et al., 2011). Yet, only a few published studies in jockeys (Dolan et al., 2012b; Waldron-Lynch et al., 2010) to date have simultaneously examined the hormonal profile, bone health, dietary and PA habits, and have yielded equivocal findings.

To the best of our knowledge, there is also limited information regarding the quality of life (QOL) of jockeys who regularly engage in weight-making practices. Chronic dietary restriction has been shown to affect not only physical health, but also mental health (e.g., depression and negative mood profiles) and other daily behaviors (e.g., eating disorders and the regular practice of forced vomiting and reliance on appetite suppressants; Wilson et al., 2014a). It is of paramount importance to consider how the current lifestyle practices of jockeys and the associated consequences may impact on their general well-being. The purpose of this study therefore was to assess markers of bone health, bone-specific PA habits, nutritional intake, and QOL of professional jockeys in Hong Kong, with gender-, age-, and body mass index-matched controls.

All participants visited the laboratory individually for data collection. Upon arrival, a written informed consent form was provided with a detailed explanation of the study. Approval of the procedure was granted by the Chinese University of Hong Kong Ethics Committee.

### Anthropometric Measurements

Height and body weight were measured using a stadiometer (Seca, Leicester, United Kingdom) and a digital scale (Tanita MC 780, Tokyo, Japan), respectively. Calibrated Harpenden calipers were used for estimation of body fat based on the sum of seven-site skinfold (Jackson & Pollock, 1978), in accordance with previous jockey research (O’Reilly et al., 2016; Warrington et al., 2009).

### Bone Health Assessment

#### Bone Mineral Density

Dual-energy X-ray absorptiometry (DXA) scanning (EXA-3000; OsteoSys, Seoul, South Korea) was used to measure the BMD of the forearms (cortical bone) and calcaneus (trabecular bone) at both sides, as previously described by our research group (O’Reilly et al., 2016). Based on World Health Organization classifications (Brown & Josse, 2002), three levels of bone condition (normal, osteopenia, or osteoporosis) can be determined from the DXA T score.

#### Serum Hormonal Markers

Early-morning-fasted blood samples (10 ml) were acquired by a qualified nurse via single venous puncture. The blood was allowed to clot, and the serum was separated by centrifugation, followed by storage at −80 °C until being sent to a pathology laboratory for analysis. Cortisol, testosterone, and 25-hydroxyvitamin D levels (the latter as an indicator of vitamin D nutritional status) were measured using a commercially available immunoassay kit (Architect; Abbott, Wiesbaden, Germany).

#### Bone-Specific Physical Activity Questionnaire

The participants’ bone-loading history from various PAs was assessed via the bone-specific physical activity questionnaire (BPAQ), a validated instrument for predicting variance in femoral neck, lumbar spine, and whole-body BMD for men (Weeks & Beck, 2008, 2012). It accounts for the different bone-loading nature of various PAs (e.g., weight bearing vs. nonweight bearing) and has a specific index for each exercise type. Using the algorithms designed by the original authors (available online: http://www.fithysign.com/BPAQ/), the BPAQ data collected (i.e., the loading index of each PA, and the length and frequency of participation) were converted into two components: (a) past BPAQ score, which reflects activities throughout the participant’s lifetime, and (b) current BPAQ score, which reflects activities in the last 12 months.

### Nutritional Analysis

Participants completed a 3-day food diary, a widely used method for nutritional analysis in practical perspective (Wilson et al., 2014a). The total food consumed, portion sizes, and preparation method were described for the 2 days prior to race day and one race day, during a “typical racing week.” Detailed instructions on how to accurately record dietary intake were provided. All completed dietary records were analyzed using the online food nutrient calculator from the Centre for Food Safety of Hong Kong (available at http://www.cfs.gov.hk/english/nutrient/fc-introduction.php).

For a more chronic overview of bone-related nutritional habits, each participant also indicated their intake frequency for a list of foods rich in calcium and vitamin D via the validated bone-specific

## Methods

### Participants and Experimental Design

Fourteen flat-racing male jockeys (representing ∼27% of the total jockey population in Hong Kong) and 14 male controls were recruited. All jockeys had at least 3 years of professional racing experience and held a Hong Kong full-time racing license. Participants in the control group were recruited by mass mail to all staff and students in a local university. Inclusion in the control group was restricted to healthy males who were recreationally active but who were not involved in any organized, structured exercise training any more than twice a week. Any participants taking medication known to affect metabolic function were excluded.

Participants completed a 3-day food diary, a widely used method for nutritional analysis in practical perspective (Wilson et al., 2014a). The total food consumed, portion sizes, and preparation method were described for the 2 days prior to race day and one race day, during a “typical racing week.” Detailed instructions on how to accurately record dietary intake were provided. All completed dietary records were analyzed using the online food nutrient calculator from the Centre for Food Safety of Hong Kong (available at http://www.cfs.gov.hk/english/nutrient/fc-introduction.php).

For a more chronic overview of bone-related nutritional habits, each participant also indicated their intake frequency for a list of foods rich in calcium and vitamin D via the validated bone-specific

### Nutritional Analysis

Participants completed a 3-day food diary, a widely used method for nutritional analysis in practical perspective (Wilson et al., 2014a). The total food consumed, portion sizes, and preparation method were described for the 2 days prior to race day and one race day, during a “typical racing week.” Detailed instructions on how to accurately record dietary intake were provided. All completed dietary records were analyzed using the online food nutrient calculator from the Centre for Food Safety of Hong Kong (available at http://www.cfs.gov.hk/english/nutrient/fc-introduction.php).

For a more chronic overview of bone-related nutritional habits, each participant also indicated their intake frequency for a list of foods rich in calcium and vitamin D via the validated bone-specific

## Methods

### Participants and Experimental Design

Fourteen flat-racing male jockeys (representing ∼27% of the total jockey population in Hong Kong) and 14 male controls were recruited. All jockeys had at least 3 years of professional racing experience and held a Hong Kong full-time racing license. Participants in the control group were recruited by mass mail to all staff and students in a local university. Inclusion in the control group was restricted to healthy males who were recreationally active but who were not involved in any organized, structured exercise training any more than twice a week. Any participants taking medication known to affect metabolic function were excluded.
food frequency questionnaire (BFFQ; Pritchard et al., 2010). The micronutrient values for each reported food item were summed, and the overall intake values were calculated.

Quality of Life
QOL was assessed using the validated World Health Organization Questionnaire (World Health Organization, 1998). The 26-item questionnaire divides QOL into the following four domains: physical, psychological, social relationship, and environmental aspects. Respective scores for each domain were calculated.

Statistical Analysis
Data analysis was conducted using SPSS for Windows (version 22; SPSS UK Ltd., Bedfont Lakes, United Kingdom). All data were presented as means ± SD unless otherwise specified. Independent t tests were used to identify intergroup differences. The significance level was set at p ≤ .05.

Results

Anthropometric Measurements
The jockey group and the control group were matched for gender, ethnicity (Chinese: n = 7; White: n = 7, for both groups), age (29.1 ± 6.1 vs. 26.0 ± 6.5 years, p > .05), and body mass index (20.3 ± 1.6 vs. 21.1 ± 1.7 kg/m², p > .05). The jockeys were significantly lighter (52.8 ± 3.7 vs. 63.7 ± 9.2 kg), shorter (161 ± 5 vs. 173 ± 7 cm), and had a lower sum of seven-site skinfold measurement (42.4 ± 9.1 vs. 72.1 ± 43.6 mm) than the controls (p < .01).

DXA Scan
The jockey group displayed significantly lower BMD at both left and right calcaneus (p < .01) than the control group, with mean T and z scores located in the clinical range for osteopenia (Table 1). Thirteen out of the 14 jockeys (93%) showed either osteopenia or osteoporosis in at least one of their calcanei. No significant difference in BMD for either forearm was found between the groups.

Serum Hormonal Markers
All samples were within the normal reference range, and no significant difference was found between the groups (all ps > .05; Table 2).

Bone-Specific Physical Activity Questionnaire
The jockey group showed a significantly lower current BPAQ score than the control group (5.61 ± 1.82 vs. 8.27 ± 2.91, p > .05). Past BPAQ scores did not show a significant group difference (68.9 ± 51.2 vs. 68.9 ± 51.0, p = .917).

Nutritional Analysis
Dietary intake data from the 3-day food record and the BFFQ of both groups are summarized in Table 3. The daily energy intake of the jockey group was significantly lower than the control group (1,340 ± 515 vs. 1,985 ± 1,046 kcal/day, p < .01). No significant difference was observed between the proportions of carbohydrate, fat, and protein in the two groups’ diets. The estimated vitamin D and calcium intake from the BFFQ also showed no significant group difference.

Table 1 BMD and T Scores of Calcanei and Forearms

<table>
<thead>
<tr>
<th></th>
<th>Jockeys (n = 14)</th>
<th>Controls (n = 14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left calcaneus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMD (g/cm²)</td>
<td>0.50 ± 0.06</td>
<td>0.63 ± 0.07*</td>
</tr>
<tr>
<td>T score</td>
<td>−1.77 ± 0.95</td>
<td>0.24 ± 1.01*</td>
</tr>
<tr>
<td>z score</td>
<td>−1.60 ± 0.90</td>
<td>0.28 ± 0.99*</td>
</tr>
<tr>
<td>Right calcaneus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMD (g/cm²)</td>
<td>0.51 ± 0.07</td>
<td>0.64 ± 0.10*</td>
</tr>
<tr>
<td>T score</td>
<td>−1.59 ± 0.97</td>
<td>0.26 ± 1.36*</td>
</tr>
<tr>
<td>z score</td>
<td>−1.42 ± 0.94</td>
<td>0.28 ± 1.32*</td>
</tr>
<tr>
<td>Left forearm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMD (g/cm²)</td>
<td>0.58 ± 0.08</td>
<td>0.51 ± 0.07</td>
</tr>
<tr>
<td>T score</td>
<td>−0.13 ± 1.29</td>
<td>−1.21 ± 1.08</td>
</tr>
<tr>
<td>z score</td>
<td>−0.01 ± 1.06</td>
<td>−1.07 ± 1.08</td>
</tr>
<tr>
<td>Right forearm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMD (g/cm²)</td>
<td>0.56 ± 0.06</td>
<td>0.54 ± 0.07</td>
</tr>
<tr>
<td>T score</td>
<td>−0.37 ± 1.06</td>
<td>−0.69 ± 1.11</td>
</tr>
<tr>
<td>z score</td>
<td>−0.22 ± 0.92</td>
<td>−0.66 ± 1.05</td>
</tr>
</tbody>
</table>

Note: Data are presented as mean ± SD. T score reference based on World Health Organization (1994) guideline: normal, >1; osteopenia, −1 to −2.5; and osteoporosis, below −2.5. BMD = bone mineral density.

* p < .01.

Table 2 Serum Hormonal Markers

<table>
<thead>
<tr>
<th></th>
<th>Jockeys (n = 14)</th>
<th>Controls (n = 14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-hydroxyvitamin D (nmol/L)</td>
<td>76.7 ± 28.7</td>
<td>62.4 ± 16.5</td>
</tr>
<tr>
<td>Testosterone (T, nmol/L)</td>
<td>20.8 ± 7.1</td>
<td>17.6 ± 4.9</td>
</tr>
<tr>
<td>Cortisol (C, µg/dl)</td>
<td>15.8 ± 4.1</td>
<td>16.0 ± 3.8</td>
</tr>
<tr>
<td>T:C ratio</td>
<td>1.42 ± 0.60</td>
<td>1.17 ± 0.50</td>
</tr>
</tbody>
</table>

Note: Data are presented as mean ± SD. Reference range: (a) Vitamin D, 23.5–130.8; (b) testosterone, 12.3–79.9; (c) cortisol, 3.7–19.4; established from the laboratory norm testing by the immunoassay kit manufacturer (Architect; Abbott, Germany), http://www.abbottdiagnostics.com/.

* p < .01.

Table 3 Dietary Data From 3-Day Record and BFFQ

<table>
<thead>
<tr>
<th></th>
<th>Jockeys (n = 14)</th>
<th>Controls (n = 14)</th>
<th>RDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy intake (kcal/day)</td>
<td>1,360 ± 515</td>
<td>1,985 ± 1,046*</td>
<td>2,000</td>
</tr>
<tr>
<td>Carbohydrate (%)</td>
<td>50.0 ± 12.1</td>
<td>43.4 ± 11.2</td>
<td>45–65</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>31.3 ± 7.3</td>
<td>38.6 ± 9.3</td>
<td>20–35</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>18.7 ± 4.2</td>
<td>18.0 ± 4.1</td>
<td>10–35</td>
</tr>
<tr>
<td>Sugar (g)</td>
<td>57.5 ± 32.8</td>
<td>52.2 ± 30.5</td>
<td>&lt;50</td>
</tr>
<tr>
<td>Calcium, 3 days (mg/day)</td>
<td>489 ± 290</td>
<td>511 ± 183</td>
<td>1,000</td>
</tr>
<tr>
<td>Calcium, BFFQ (mg/day)</td>
<td>753 ± 696</td>
<td>777 ± 672</td>
<td>1,000</td>
</tr>
<tr>
<td>Vitamin D, BFFQ (IU/day)</td>
<td>97.8 ± 98</td>
<td>82.2 ± 69</td>
<td>600</td>
</tr>
</tbody>
</table>

Note: Data are presented as mean ± SD. RDI= recommended underreporting intake for average healthy adults based on the guideline of the Centre for Food Safety of Hong Kong (2010); BFFQ = bone-specific food frequency questionnaire.

* p < .01.

IJSNEM Vol. 28, No. 4, 2018
Quality of Life

No significant difference was found between the respective scores in all four domains of the QOL (Table 4).

Discussion

This study aimed to simultaneously examine, for the first time, bone health biomarkers, bone-specific PA habits, nutritional intake, and QOL of Hong Kong-based professional jockeys and compared this data where possible with accepted clinical norms. A group of age-, gender-, ethnic-, and body mass index-matched healthy controls was included to minimize the regional factors (e.g., climates and sociocultural environment) that may affect the conclusion of the current study. Our results revealed suboptimal bone conditions at calcanei in a cohort of professional jockeys, which may be attributed to chronic dietary weight-making practices and the lack of bone-loading PAs. We also added novelty to existing jockey research by examining the QOL among this population.

DXA results revealed a significantly lower BMD at both left and right calcanei for the jockey group compared with the control group. Thirteen out of the 14 jockeys (93%) showed either osteopenia or osteoporosis in at least one of their ankles based on the World Health Organization classification (Brown & Josse, 2002). These results are in agreement with a recent report in Hong Kong jockeys (O’Reilly et al., 2016) and with previous studies that demonstrated the prevalence of low BMD from whole body, hip, and lumbar spine measurements among jockeys in Western Europe (Dolan et al., 2012a; Warrington et al., 2009). Indeed, BMD obtained by DXA has been identified as one of the most predictive and relevant factors for bone fracture risk (Wilson et al., 2014a).

The majority of studies conducted in jockeys to date have assessed BMD from whole body, hip, and lumbar spine using central DXA measurements (Dolan et al., 2012a; Warrington et al., 2009). The calcaneus has a similar composition as the vertebral centrum, comprised of approximately 90% trabecular bone and 10% cortical bone, and the clinical relevance of its measurement has been well established (Sweeney et al., 2002; Vogel et al., 1988). While recent literature suggests that calcaneal quantitative ultrasound measurements may not sufficiently predict osteoporosis risk due to the lack of consensus on device-specific cutoff values (Thomsen et al., 2015), measurement of calcaneal BMD using DXA technique has been shown to be a predictor of osteoporosis-associated fracture occurrence (Cheng et al., 1997; Cummings et al., 1993; Rupprecht et al., 2007) and has been shown to be as effective as BMD measured at lumbar spine, proximal femur, and proximal and distal radii (Black et al., 1992; Wasnich et al., 1987) in predicting fracture risk. Moreover, using similar measurement to assess calcaneal BMD as in the present study, Sweeney et al. (2002) compared peripheral calcaneal measurements with central DXA measurements and found that a peripheral DXA calcaneal T score of ≤0 was highly sensitive in predicting osteopenia and osteoporosis at the femoral neck and lumbar spine (Sweeney et al., 2002).

Given the high-risk nature of horse racing, where high-speed falls and bone fractures occur frequently (Abu-Zidan & Rao, 2003; Rueda et al., 2010; Warrington et al., 2009), the low BMD at the calcanei found in the present study and its associated risk of fractures should therefore be of particular concern for jockeys in Hong Kong.

It is also interesting to highlight that no significant difference was found for either forearm between the groups in the current study. The mean T scores for both forearms of the jockey group were within the normal clinical range, while the control group was in the osteopenia range in left forearm. Upon close examination of the raw data, a possible outlier in the control group was identified (T score = -3.40 for left forearm). If this data were excluded, the mean T score for the control group would be within normal range (T score = -0.89 for left forearm). However, since the participant did not report any history of fracture or abnormal physical condition, his data were retained for analysis.

Although the exact bone-loading nature of horse racing remains largely unknown, our data showing relatively high BMD T scores at forearms (compared with the T scores at calcanei) in the jockey group, could suggest a site-specific bone-loading response to horse racing, as has been previously reported (Greene et al., 2013). It has been suggested that osteogenic loading can be site specific and related to the strain placed on particular bone sites during participation in that sport (Morel et al., 2001). Using peripheral quantitative computed tomography, suboptimal bone health at the distal tibia (lower limb), but relatively high BMD at the ulna and radius (forearm), has been reported in jockeys (Greene et al., 2013). It is speculated that the ground reaction force acting on the lower limbs of jockeys may be limited by their characteristic riding posture and prolonged sitting on horses (Cullen et al., 2009). However, the sport-specific stimulus of horse riding (i.e., arm movements in multiple directions) may positively influence forearm bone strength and be protective against otherwise deleterious bone health practices such as low energy intakes as aforementioned. In addition, the lower calcaneal BMD found in the jockeys may also be due to lower body weight and the consequent decreased everyday loading of the jockeys versus controls. Further research should consider matching the body weight of the controls and jockeys to confirm the above speculation.

In relation to nutritional analysis, the daily energy intake of the jockey group was significantly lower than that of the control group (1,360 ± 515 vs. 1,985 ± 1,046 kcal/day) and was well below the recommended intake of 2,000 kcal for healthy adults in Hong Kong (Centre for Food Safety of Hong Kong, 2010). This finding was unsurprising, as previous studies worldwide (Table 5) have also reported similar ranges of daily intake for elite-level jockeys by the self-reported food record method (3–7 days). Although under-reporting is a common limitation for self-reported food records (O’Loughlin et al., 2013), from the practical point of view, it is still considered a valid method for a comprehensive overview of the exact dietary intake of individuals over a period of time (Wilson et al., 2014a). Our data did not reveal a significant difference in the proportion of macronutrients (i.e., carbohydrate, fat, and protein) between the two groups. Calcium and vitamin D intake assessed via the validated BFFQ also showed no significant group difference. This similarity in macronutrient balance and micronutrient intake would appear to suggest that a chronic energy deficit is the primary concern, along with the problems of food frequency (e.g., sporadic

<table>
<thead>
<tr>
<th>Domains</th>
<th>Jockeys (n = 14)</th>
<th>Controls (n = 14)</th>
<th>t test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>16.1 ± 1.7</td>
<td>15.5 ± 1.2</td>
<td>0.291</td>
</tr>
<tr>
<td>Psychological</td>
<td>15.9 ± 1.9</td>
<td>14.9 ± 2.0</td>
<td>0.325</td>
</tr>
<tr>
<td>Social relationship</td>
<td>16.6 ± 1.6</td>
<td>16.0 ± 1.3</td>
<td>0.769</td>
</tr>
<tr>
<td>Environmental</td>
<td>15.8 ± 2.2</td>
<td>16.0 ± 0.8</td>
<td>0.581</td>
</tr>
</tbody>
</table>

*Note. Data are presented as mean ± SD. Lowest score = 4 and highest score = 20.*
Table 5  Average Reported Daily Energy Intake of Professional Male Flat Jockeys Worldwide Using the Food Diary Method

<table>
<thead>
<tr>
<th>Study</th>
<th>Total jockeys</th>
<th>Country</th>
<th>Average daily energy intake (kcal)</th>
<th>Duration (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>14</td>
<td>Hong Kong</td>
<td>1,360</td>
<td>3</td>
</tr>
<tr>
<td>Wilson et al. (2013)</td>
<td>19</td>
<td>United Kingdom</td>
<td>1,455</td>
<td>7</td>
</tr>
<tr>
<td>Dolan et al. (2011)</td>
<td>11</td>
<td>Ireland</td>
<td>1,667</td>
<td>7</td>
</tr>
<tr>
<td>Greene et al. (2013)</td>
<td>11</td>
<td>Australia</td>
<td>1,786</td>
<td>3</td>
</tr>
<tr>
<td>Leydon and Wall (2002)</td>
<td>6</td>
<td>New Zealand</td>
<td>1,619</td>
<td>7</td>
</tr>
</tbody>
</table>

Acknowledgments

The authors would like to acknowledge the significant role played by the Hong Kong Jockey Club in facilitating this research project to take place, in particular; Mr. Bill Nader and Mr. Steve Railton. Finally, the authors would like to acknowledge each of the professional jockeys who have given up their time to participate in this study. All authors were involved in the study design, data collection, analysis, interpretation, manuscript preparation, and approved the final version of the paper. The authors have nothing to declare regarding any potential conflicts of interest.

References


