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Physical and Lifestyle Factors Influencing Bone Density in Jockeys: A Comprehensive Update of the Bone Density Status of Irish Jockeys

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ABSTRACT

International Journal of Exercise Science 14(6): 324-337, 2021. Compromised bone density in jockeys has previously been identified as an important health and safety concern in horseracing. Despite this, no update on the bone density status in Irish jockeys has been provided in the past decade. The study aimed to conduct a comprehensive update of the current bone density status in professional Irish jockeys and identify possible contributory physical and lifestyle factors. Eighty-five professional male jockeys (flat n = 39; national hunt (NH) n = 46) completed a dual-energy X-ray absorptiometry (DXA) scan for the assessment of body composition and bone mineral density (BMD) at the lumbar spine (LS), femoral neck (FN) and hip, 24-hour food recall, bone-specific physical activity questionnaire (BPAQ) and lifestyle questionnaire on weight making practices and injury history. Z-scores were interpreted to assess current bone density status. Correlation analysis was used to identify physical and lifestyle factors associated with bone mineral apparent density (BMAD). Results revealed a high prevalence of low BMD (Z-score < - 1.0) at the LS (44%), FN (15%) and hip (29%) in Irish jockeys. Analysis of jockeys physical characteristics found a positive relationship with the LS but not FN BMAD. Riding experience and timing of weight cut in NH and the practice of cutting weight in flat jockeys negatively influenced BMAD sites, while supplement use in flat jockeys displayed a positive effect on LS BMAD. Findings indicate the need for targeted individualised support strategies. Further investigation is required into jockey-specific intervention strategies that promote the development of optimal bone health in professional jockeys.

KEY WORDS: jockey, body composition, weight cutting, weight-category sport, DXA, bone mineral density

INTRODUCTION

The high-risk nature of horse racing has led to growing concern for the health and welfare of jockeys in the last decade. Managing weight to meet the strict weight classifications to maximise racing opportunities is an essential part of life as a professional jockey. In Irish racing, the weight classifications range from 52.7 kg to 64 kg and 62 kg to 76 kg (inclusive of riding equipment) for flat and national hunt (NH; jump) races, respectively. Inexperienced flat (apprentice) and NH (conditional) jockeys race at lighter weights to increase racing opportunities. The necessity to align body mass with the stipulated competition riding weights over the protracted racing season results in many jockeys having to make-weight all year round (35). This chronic weight cycling is further exacerbated due to the unpredictability of racing weights and the typical short notice period (between 24 to 48 hours) for a jockey to reach the assigned weight (6, 38). The implications of this continuous weight cycling coupled with an elevated risk of falls and injuries (22), has resulted in research investigating bone mineral density (BMD) and the prevalence of poor bone density in jockeys (5, 14, 25, 35, 39, 42).

Research by Warrington et al., (35) reported 59% of flat and 40% of NH jockeys displayed low bone density in one or more of the total body, hip or lumbar spine (LS) assessed using dual-energy x-ray absorptiometry (DXA). Subsequent investigations in Ireland found jockeys had significantly lower bone mass compared to other weight category athletes (elite amateur boxers) and active controls (5). These findings were used to establish jockey education and support services in Ireland such as dietary workshops and conditioning exercise sessions to help promote the overall health and performance of jockeys particularly in relation to effective weight management using evidenced based practices. More recently, a large scale assessment of professional jockeys found flat (76%) and NH (52%) jockeys to have low BMD at the LS (14). Of note, the study was restricted to newly licenced jockeys, and while the two and half year study captured a representative sample of entry-level jockeys, it provides no indication of the bone density of more experienced jockeys (14). Therefore, there has been no updated large-scale bone density assessment of Irish jockeys and/or experienced jockeys for over a decade.

A number of lifestyle factors including low energy availability, inconsistent physical activity outside of racing, poor food choice, inadequate vitamin D and calcium intake and acute weight loss strategies such as sauna use, exercising to sweat and restricted food intake have been widely reported in jockey groups (8, 16, 25, 26, 38, 42). Moreover, the weight-bearing nature of horse racing is largely unknown, yet it is hypothesised that jockeys receive insufficient loading to elicit a positive site-specific bone response (11). Despite this, the impact of these lifestyle and weight loss practices on bone density in jockeys remains unclear. A better understanding of the interaction of these influencing factors on bone density from a large representative population of professional jockeys will help to improve the provision of bone-health services and resources. Therefore, the aim of the study was to conduct a large assessment and provide a comprehensive update of the current bone density status in Irish professional jockeys as well as examining physical and lifestyle factors associated with bone density for this athletic population.

METHODS

Participants

Eighty-five professional male jockeys (*n* = 39 flat (21 apprentice); *n* = 46 NH (24 conditional) participated in this study (representing 59% of flat and 48% of NH jockeys in Ireland at the time of data collection). All participants were injury-free and held a current racing licence. The testing session involved: 1) Measurement of height and body mass; 2) Hydration testing; 3) DXA scan; 4) 24-hour food recall; 5) Completion of a bone-specific physical activity questionnaire (BPAQ); 7) Completion of a lifestyle questionnaire on weight making practices and injury history. Written informed consent was provided by each participant. Since a racing licence is permitted at 16 years of age, any jockey above 16 years were included in this study and provided participant assent and parental consent. Ethical approval was granted by a local Third Level Institution's Research Ethics Committee, and the research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (21).

Protocol

Body mass was assessed with participants in minimal clothing using electronic scales (SECA, Vogel & Halke GmbH, Hamburg, Germany) measured to the nearest 0.1 kg. Height was measured with a stadiometer incorporated in the scale to the nearest 1 cm. Body mass index (BMI) was calculated as weight in kilograms (kg) divided by height in meters squared ($kg \cdot m^{-2}$).

A urine sample collected at the start of the testing session was assessed for urine specific gravity (Usg) measured using a handheld refractometer (Atago, USA). As classified in previous research, euhydration was defined by a Usg of ≤ 1.020 (30).

Dual-energy X-ray absorptiometry (DXA) (Lunar Prodigy scanner, software version 16) was used to measure bone mineral density (BMD; $g \cdot cm^{-2}$) and bone mineral content (BMC; g) at the total body, LS (L1 – L4), femoral neck (FN) and total hip. Bone mineral apparent density (BMAD; $g \cdot cm^{-3}$) was calculated for the LS and FN as previously described by Dolan et al., (5). Age matched BMD Z-scores were derived for each jockey and sub-classified into ≤ −1 and ≤ −2 for the LS, FN or total hip using the 'National Health and Nutrition Examination Survey (NHANES) 2008' reference database.

Body composition data from the DXA total body scan was extrapolated to assess lean and fat mass, body fat percentage (BF%) and lean mass index (LMI) calculated as lean mass in kilograms (kg) divided by height in meters squared ($kg \cdot m^{-2}$). Scanning protocols were implemented as per techniques previously described to maximise technical reliability and minimise error (20). Given the lifestyle demands of jockeys, it was not possible to standardise the time of testing. However, participants were advised to avoid exhaustive exercise in the previous 24 hours, be hydrated, have voided and fasted or have eaten only lightly (< 500 g) (15) before attending the testing session. One trained technician performed and interpreted all examinations to ensure consistency.

Dietary intake for each participant was collected and analysed via INTAKE24, a validated web-based 24-hour dietary recall tool (31). Each jockey was instructed to list all the food and drink consumed within the 24 hours of their last non-racing day to ensure the 24-hour recall was standardised. Probing questions related to their food and drink input were asked about commonly omitted food items such as condiments and sauces. Portion size and any leftovers were estimated using a range of different quantifying guides including food photographs (presented as a portion range or `as served`), standard portion descriptions (teaspoon and ml) and sliding scales used for fluid estimation. Total daily energy intake (kcal), macronutrients (carbohydrate (Cho)(g) and protein (g) relative to body mass (g/kg) and fat (g) presented as % of energy intake) and calcium (mg) were used for further analysis.

The bone-loading history for each participant was assessed using the validated BPAQ instrument (36). The online instrument predicts parameters of bone strength based on the loading index of various weight-bearing and non-weight-bearing physical activities and the length and frequency of an individual's participation. Respondents recorded type, frequency and years of physical activity involvement. A past, current and total BPAQ score was calculated, reflecting the physical activities throughout the participant's lifetime until the last 12 months, activities in the last 12 months and activities from the combined past and current. The higher the score, the better the bone-loading experience from exercise.

A questionnaire, based on the health and lifestyle questionnaire previously validated and administered amongst professional jockeys (8), was completed by participants in a semi-structured interview format to record lifestyle information including racing history, fracture incidence, weight making practices and diet. The instrument containing 32 open- and closed-ended questions collected data on riding experience, approximate winners, fracture history including prevalence and site, weight making methods and time frame of weight management. Participants also provided information on smoking and dietary supplement and alcohol use. Where applicable, participants were instructed to select as many options as deemed personally relevant.

Statistical Analysis
All data were analysed using SPSS for Windows, version 25 (SPSS Inc., Chicago, Illinois, USA). Descriptive characteristics, bone measurements and body composition data were calculated and presented as mean ± standard deviation (SD) for continuous variables and frequency for categorical variables. Normality was assessed. An independent samples t-test or Mann-Whitney U Test examined the differences between the groups depending on data distribution. A chi-squared was used to examine categorical variables. Effects size for the independent samples t-test were calculated and classified according to Cohen's d (small = 0.01, moderate = 0.06, and large = 0.14) (2).

Spearmen rank (Rho) correlation was used to determine the strength of the relationship between bone mass (LS and FN BMAD) and factors associated with bone density including physical (height, body mass, BMI, LM, FM, BF% and LMI) and lifestyle (energy, protein, fat, Cho and calcium intake, hydration status, supplement use, BPAQ score, riding experience, weight making practices and fracture incidence). BMAD was used as it provides an estimation of volumetric bone density and thus accounts for the influence of bone size on BMD measurements. Rho values are reported for correlation coefficient scores. Statistical significance was set at $p < 0.05$ for all tests.

RESULTS

All demographic, anthropometric and body composition characteristics are presented in Table 1. Flat jockeys were significantly shorter, lighter and had lower fat mass and lean mass compared to NH jockeys ($p < 0.05$). There was no significant difference in BF% despite large variations between riding licenses (range: flat 8.8% to 23.9%; NH 6% to 31.2%). The group of jockeys were classified as hydrated with a mean Usg of 1.018 ± 0.007 however, Usg values ranged from 1.004 to 1.033 (flat 1.004 – 1.028; NH 1.005 – 1.033).

Table 1: Demographic, anthropometric and body composition information according to type of racing licence.

	All	Flat	NH	Flat vs NH Effect size
Age (yrs)	27.3 ± 7.8	26.8 ± 9.6	27.7 ± 5.9	0.12
Riding Experience (yrs) [range]	9.4 ± 7.5 [1.0 – 36.0]	9.2 ± 9.9 [1.0 – 36.0]	9.2 ± 5.8 [1.0 – 22.0]	0.07
Number of Winners [range]	190.9 ± 335.1 [0.0 – 1900.0]	248.2 ± 362.6 [0.0 – 1500.0]	142.4 ± 305.5 [1.0 – 1900.0]	0.32
Height (cm)	171.2 ± 6.0	167.3 ± 5.4	174.6 ± 4.4	1.50*
Body mass (kg)	61.1 ± 6.0	55.7 ± 3.2	65.7 ± 3.2	2.90*
BMI ($kg \cdot cm^{-2}$)	20.8 ± 1.5	20.0 ± 1.3	21.6 ± 1.2	1.27*
Hydration (Usg)	1.018 ± 0.007	1.019 ± 0.007	1.018 ± 0.008	0.08
Body Fat (%)	15.1 ± 3.2	14.9 ± 3.0	15.3 ± 3.4	0.13
Lean Mass (kg)	49.8 ± 5.0	45.7 ± 3.1	53.4 ± 3.4	2.32*
Fat Mass (kg)	8.9 ± 2.2	8.0 ± 1.7	9.6 ± 2.3	0.83*
LMI ($kg \cdot cm^{-2}$)	17.0 ± 1.2	16.4 ± 1.0	17.5 ± 1.1	1.09*

Data presented as mean ± SD, * $p < 0.05$; *NH* national hunt *BMI* body mass index, *LMI* lean mass index

Bone mass measurements are presented in Table 2. Flat jockeys had significantly lower BMD and BMC at all measured sites ($p < 0.05$). Prevalence of low BMD (Z-score ≤ - 1.0) was displayed in jockeys at the LS (44%), FN (15%) and total hip (29%). Further, the percentage of flat jockeys with a Z-score less than or equal to -1.0 at the LS (59% vs 30%), FN (26% vs 7%) and total hip (49% vs 13%) was significantly greater than their NH counterparts ($p < 0.05$).

Table 2: Bone mass information according to the type of racing licence.

		All	Flat	NH	Flat vs NH Effect size
TB BMD (g·cm^{-2})		1.198 ± 0.092	1.115 ± 0.081	1.244 ± 0.075*	1.28*
TB BMC (g)		2616.94 ± 306.03	2391.27 ± 210.56	2808.27 ± 236.26*	1.85*
TB Z-score [range]		0.1 ± 0.9 [-1.50 – 1.90]	- 0.3 ± 0.8 [-1.50 – 1.30]	0.5 ± 0.8* [-1.20 – 1.90]	1.10*
LS BMD (g·cm^{-2})		1.122 ± 0.119	1.072 ± 0.113	1.163 ± 0.109*	0.81*
LS BMC (g)		65.07 ± 10.54	58.87 ± 8.46	70.32 ± 9.25*	1.29*
LS BMAD (g·cm^{-3})		0.125 ± 0.013	0.125 ± 0.014	0.124 ± 0.012	0.08
LS Z-score [range]		-0.8 ± 0.9 [-2.80 – 1.20]	-1.2 ± 0.9 [-2.80 – 0.80]	-0.5 ± 0.9 * [-2.30 – 1.20]	0.75*
LS	≤ - 1.0	37 (44)	23 (59)	14 (30)	0.29*
n (%)	≤ - 2.0	11 (13)	8 (21)	3 (7)	0.30*
FN BMD (g·cm^{-2})		1.065 ± 0.121	1.026 ± 0.115	1.100 ± 0.118*	0.62*
FN BMC (g)		5.57 ± 0.82	5.19 ± 0.68	5.89 ± 0.80*	0.95*
FN BMAD (g·cm^{-3})		0.392 ± 0.046	0.389 ± 0.048	0.395 ± 0.044	0.14
FN Z-score [range]		0.0 ± 0.9 [-1.80 – 2.70]	- 0.3 ± 0.9 [-1.80 – 2.00]	0.1 ± 0.8* [-1.60 – 2.70]	0.64*
FN	≤ - 1.0	13 (15)	10 (26)	3 (7)	0.27*
n (%)	≤ - 2.0	-	-	-	-
Total Hip BMD (g·cm^{-2})		1.025 ± 0.114	0.985 ± 0.106	1.057 ± 0.111*	0.68*
Total Hip BMC (g)		34.42 ± 4.72	32.11 ± 3.85	36.38 ± 4.54*	1.01*
Total Hip Z – score [range]		-0.419 ± 0.869 [-2.50 – 2.10]	-0.700 ± 0.860 [-2.50 – 1.70]	-0.169 ± 0.807* [-2.30 – 2.10]	0.64*
Total Hip	≤ - 1.0	25 (29)	19 (49)	6 (13)	0.39*
n (%)	≤ - 2.0	3 (4)	2 (5)	1 (2)	0.39*

Data presented as mean ± SD, * $p < 0.05$; *NH* national hunt *TB* total body, *BMD* bone mineral density, *BMC* bone mineral content, *BMAD* bone mineral apparent density, *LS* lumbar spine, *FN* femoral neck

Energy, macronutrient and calcium intake are presented in Table 3. Energy intake range varied greatly (610.9 kcal to 3648.7 kcal), yet there was no significant difference amongst the jockeys ($p > 0.05$). Mean calcium intake was above the recommended dietary allowance (RDA) of 800 mg, however, intakes ranged greatly in both the flat (192.0 mg to 1850.2 mg) and NH (218.3 mg to 1778.0 mg) jockeys.

Table 3: Energy, macronutrient and calcium intake according to the type of racing licence.

	All	Flat	NH	Flat vs NH Effect size
Energy (kcal)	1860.7 ± 602.2	1728.5 ± 694.7	1972.4 ± 497.5	0.41
[range]	[610.9 – 3648.7]	[610.9 – 3648.7]	[930.8 – 3314.0]	
Fat (g)	74.8 ± 34.6	65.2 ± 36.1	82.8 ± 31.8	0.52*
[% of EI]	[36.2]	[33.9]	[38.2]	
Protein (g)	76.4 ± 35.8	75.5 ± 49.1	76.9 ± 19.1	0.04
[g/kg]	[1.3 ± 0.6]	[1.4 ± 0.8]	[1.3 ± 0.4]	
Cho (g)	230.1 ± 72.96	215.11 ± 78.6	243.2 ± 67.0	0.39
[g/kg]	[4.1 ± 0.6]	[4.1 ± 2.0]	[4.0 ± 1.9]	
Calcium (mg)	838.3 ± 387.1	793.9 ± 450.1	872.3 ± 327.4	0.20
[range]	[192.0 – 1850.2]	[192.0 – 1850.2]	[218.3 – 1778.0]	

Data presented as mean ± SD, * $p < 0.05$; *NH* national hunt *Cho* carbohydrate, *EI* energy intake

From the self-reported lifestyle and fracture history questionnaire, 41% of participants reported using dietary supplements including vitamin D, multivitamin, fish oils and high-dose B vitamin complex plus vitamin C and minerals (Berocca®). Just under half the participants smoked cigarettes (49%) while 59% of participants drank alcohol at least once a fortnight. The most common method for making weight was sauna (59%) followed by hot baths (52%), exercising wearing sweat suits (48%), excessive exercising (36%) and severe dieting (17%), with 92% of participants having to cut weight for racing. The reported frequency of weight cutting was 34% every 48 hours, 29% once a week and 37% every month. When asked about losing a set amount of weight (2 kg/4.4 lbs), 71% said they would begin weight cutting less than 36 hours before the race. No significant difference was shown between flat (69%) and NH (72%) jockeys in relation to weight cutting 36 hours before a race ($p > 0.05$).

Mean BPAQ total score was 41.9 ± 20.5 (42.3 ± 19.5 and 41.5 ± 21.4, flat and NH respectively) with the range between 7.2 and 104.1. Past and current BPAQ scores were not significantly different between flat (75.99 ± 34.30 and 8.50 ± 11.28, past and current BPAQ respectively) and NH jockeys (74.72 ± 39.65 and 8.30 ± 8.37, past and current BPAQ respectively) ($p > 0.05$).

Most participants (73%) indicated to having experienced a bone fracture (59% and 85%, flat and NH respectively) in their lifetime with an average of 3.8 ± 5.4 fractures (1.5 ± 1.7 and 5.8 ± 6.6 flat and NH respectively) (range 0 – 36) per participant including recurring fractures.

Correlation data between BMAD sites and significant associated physical and lifestyle factors according to the type of racing licence ($p < 0.05$) are presented in Table 4. A medium positive correlation was identified between LS BMAD and body mass for flat (rho = 0.47, $p = 0.003$) and NH jockeys (rho = 0.40, $p = 0.006$). Lean mass and/or LMI showed a significant medium positive correlation at the LS BMAD for all participants and between racing licences ($p < 0.05$). Flat jockeys showed a positive medium correlation at the LS BMAD with supplement use (rho = 0.32, $p = 0.049$) and a negative medium correlation at the FN BMAD with weight cutting (rho = - 0.34, $p = 0.032$). A medium to large negative correlation was found between LS BMAD and timing of weight cut (rho = - 0.32, $p = 0.033$), FN BMAD and riding experience (rho = - 0.56, $p = 0.01$) and FN BMAD and number of winners (rho = - 0.32, $p = 0.030$) in the NH jockeys.

Table 4. Correlation data between BMAD sites and significant associated factors according to type of racing licence ($p < 0.05$).

Bone Site	All	Flat	NH
LS BMAD	Height (rho = 0.29) Body mass (rho = 0.50) BMI (rho = 0.41) Lean mass (rho = 0.46) Fat mass (rho = 0.29) LMI (rho = 0.38) Timing of weight cut (rho = - 0.27)*	Body mass (rho = 0.47) BMI (rho = 0.44) LMI (rho = 0.40) Supplement use (rho = 0.32)	Body mass (rho = 0.40) Lean mass (rho = 0.30) Timing of weight cut (rho = - 0.32)*
FN BMAD	Riding experience (rho = - 0.34)*	Weight cutting (rho = - 0.34)*	Riding Experience (rho = - 0.56)* No. of winners (rho = - 0.32)*

BMAD bone mineral apparent density, *BMI* body mass index, *LMI* lean mass index; *A negative value indicates that BMAD decreases: as time reduces for weight cutting before racing; as years of riding experience increase; for those weight cutting; as number of winners increases.

DISCUSSION

This cross-sectional study is the first comprehensive update on the bone density of Irish jockeys following the introduction of jockey health and performance programmes and is the largest representative sample of professional jockeys (59% of flat and 48% of NH) in Ireland ever collected. Results from this study confirm a high prevalence of low BMD at the LS (44%), FN (15%) and total hip (29%) in Irish jockeys, highlighting limited change in BMD status in these high-risk athletes in the previous decade, despite many health and safety strategies being implemented. Results showed that NH jockeys have higher bone mass at all absolute and calculated bone sites compared to flat jockeys. Analysis of physical and lifestyle factors revealed a positive effect of body mass and lean mass on bone density in all jockeys, as well as the favourable influence of supplement use on bone mass in flat jockeys. However, the timing of weight loss and riding experience in NH jockeys and weight cutting in flat jockeys had a negative impact on bone markers, suggesting acute weight loss and race riding may have adverse effects on bone density.

Results of this study found a large proportion of jockeys in Ireland have a low BMD Z-score of < - 1.0 at the LS, FN and total hip. Between jockey groups, the prevalence of low BMD at the FN (26% vs 7%) and total hip (49% vs 13%) were over three times higher in flat compared to NH jockeys, and double at the LS (59% vs 30%) respectively. Given the awareness from previous research of poor bone density in jockeys and limited signs of improvement, the findings of this study are concerning for the health and welfare of jockeys (7, 11, 14, 26, 35, 41). Jackson et al., (14) showed a similar trend of reduced bone mass in jockeys from the UK however, the prevalence of low BMD was slightly higher compared to the present study. The authors reported higher rates of low BMD at the LS (76% vs 52%) and FN (34% vs 9%) for flat and NH jockeys, respectively. The mean age profile of the jockeys was considerably lower (18.5 years and 20.7 years, flat and NH respectively) compared to the present study, suggesting the difference in prevalence rates may be due to the variance in physical maturity (14).

Comparison of the present results with previous research from Ireland indicates there has been little change in the bone density status of jockeys. Warrington et al., (35) observed reduced bone mass using a T-score in a group of professional jockeys from Ireland. The authors reported higher rates of low BMD in flat compared to NH jockeys at the hip (41% vs 20%) but not at the LS (35% vs 40%) (35). Yet, direct comparison to this research is difficult as T-scores were calculated instead of Z-scores (28). Z-score is preferred when reporting BMD in individuals under 50 years of age (13). However, caution must be taken when interpreting T- and Z-scores of smaller athletes such as jockeys as bone density estimates from general population data are not athlete-specific and may be slightly misleading (29). Similarly, Dolan et al., (5) reported sub-optimal bone density in a group of flat and NH jockeys compared to a group of boxers and recreationally active controls. Despite not reporting Z-scores, the authors findings of low BMD and BMC at the FN are comparable to the present study. Results in the present study show that flat jockeys presented with a higher rate of low bone density at all sites compared to NH jockeys. While the lower weight ranges in flat jockeys have been suggested as a possible cause for reduced BMD (35), volume adjusted BMD at the LS and FN indicated there was no difference between flat and NH jockeys. Thus, further research is warranted to investigate the reasons why bone density differs between flat and NH jockeys. Thus, pending further research, it is proposed that the introduction of jockey support services including dietary workshops and exercise programs have not changed the status of bone density in Irish jockeys as low BMD remains prevalent in flat and NH jockeys in Ireland with particularly worrying rates of very low bone density in flat jockeys. These findings provide evidence for the design and implementation of an industry-led jockey specific bone health intervention programme focused on optimising bone parameters and promoting long-term bone health, decreasing bone fragility and therefore potentially reducing the risk of fractures upon impact from falls.

This study reports the physical characteristics of jockeys, including body mass, height and lean mass, positively influence LS BMAD. This is not surprising given the mechanostat theory, such that lean mass and associated muscular force during growth or in response to increased loading will affect bone mass, size and strength (1). Dolan et al., (5) highlighted this interaction of lean mass and height when assessing the covariates of bone mass between a group of jockeys, boxers and active controls. Yet, the authors indicated participation in high impact sports like boxing may provide additional protective effects independent of lean mass and height (5). Accordingly, it has been shown different exercise modalities exert a site-specific bone response, thus the LS may be more responsive to changes in lean mass and other physical characteristics from horse riding compared to the FN (9, 33). Nevertheless, the results from the present study found the LS site to have the highest percentage of low BMD in both jockey licences, suggesting the intensity of horse riding may not elicit a sufficient bone response (28). Jockeys often refrain from exercise outside of racing due to a perceived fear of increasing muscle mass and consequently, the impact on making weight (38). The results of the predicted bone loading score (BPAQ) showed no relationship between bone loading history and bone markers, which may be explained by the large variability between the bone loading scores reported. While the current and past BPAQ scores were higher than previous research in jockeys (25), responses to the questionnaire are based on recall which possesses inherent error that can result in over- and under-estimation of bone loading scores. It has been suggested that jockeys receive insufficient bone loading stimulus through horse riding (4), and despite the need for investigation into the loading patterns of horse riding, recent research has confirmed inconsistency with the physical preparation strategies of jockeys (16). A quarter of the jockeys surveyed reported not taking part in any other form of physical activity outside of racing (16). This is a worrying trend as exercise particularly high-impact unaccustomed loads like skipping and jumping are important for bone growth and the prevention of bone loss (9).

Previous research has suggested that inadequate dietary intake and poor nutrition practices are a major influence of impaired bone density in jockeys (8, 26, 39). Results from the current study showed no relationship between dietary intake and bone markers in this cohort of jockeys however, this may be the result of the large variability displayed in dietary intake. Calcium intake was on average above the recommended EAR (800 mg) yet, there was a broad range of intakes. While this highlights that some jockeys consumed very low levels of calcium, it demonstrates that the cross-sectional design of this study was limited in capturing only a single 24-hour recall, thus the dietary records may not have been a true reflection of some participants daily intake (17). Conversely, the use of dietary supplements in flat jockeys was identified as having a positive association with LS BMAD, suggesting dietary supplements may play an important role in reducing bone losses in a vulnerable athletic population likes jockeys. Currently, Irish jockeys with low BMD are recommended to take a vitamin D supplement. However, due to limited information on dietary supplement usage from the present study, further research is necessary to determine what supplements may be beneficial for jockeys and the appropriate dosing protocols.

Results indicate the physical differences between the riding weight classifications for flat and NH however, weight management appears a common issue in both cohorts. The majority (71%) of jockeys reported weight cutting less than 36 hours before racing, with saunas (59%) and exercising while wearing a sweat suit (52%) the most common methods used to maintain a low body mass. Timing of weight cut had a negative relationship with LS BMAD in NH jockeys, suggesting that making weight over a short time frame may be associated with impaired bone density. Rapid weight loss is an accepted culture within the sport, with archaic practices more common place than scientific evidenced based strategies (5, 38). Similarly, analysis found the practice of weight cutting negatively affected bone mass at the FN BMAD in flat jockeys. Given the weight management demands of horse racing, the levels of fat mass observed in the present group of jockeys is in line with recent literature (10, 40). However, fat mass levels have increased compared to previous research and appear higher than those reported in athletes from other weight-sensitive sports including boxing and taekwondo (5, 27, 35), suggesting that there is an opportunity to reduce body fat rather than rely on rapid weight loss techniques (37). Alternative strategies for weight management, such as bespoke nutrition interventions, have been suggested to help reduce bone turnover and subsequently, the risk of fracture (34, 37).

It is possible the early emphasis of restriction and the chronic practice of making weight can have immediate and longer-term health risks for jockeys (8). Results showed riding experience and number of winners had a negative relationship with FN BMAD in NH but not flat jockeys.

This is concerning for NH jockeys given that fractures represent the highest percentage of their overall injuries (22). With a higher success rate, the demand for a jockey to ride in each race is likely to increase and subsequently, more experience is achieved throughout a lengthy career. However, this may lead to reduced BMD at the FN due to sub-optimal recovery between races, chronic weight cycling and limited time off for injury repair (12, 23, 32). Thus, targeted fracture prevention initiatives including nutrition education and falls training are important for the long-term health, safety and well-being of jockeys. While in flat jockeys the findings of no impact between years of race riding and BMD are supported by previous research, yet further investigation is required to determine the anomalies identified in the bone health of jockeys (42). Wilson et., (42) suggested the low BMD levels reported in jockeys may be as a result of an initial bone density reduction during their adolescents that persists without further decrease throughout their career. The authors recommend assessing the BMD of aspiring adolescent jockeys prior to commencing a significant amount of horse riding and subsequently a career of chronic weight management. Moreover, the long-term impact of chronic weight cycling on bone density in jockeys is not fully understood with conflicting research in retired jockeys (3, 19). Future research is required to longitudinally track the bone density, physical characteristics and dietary intake of jockeys to assess the long-term effects of a career in horse racing and subsequently, implement strategies to protect bone health throughout their racing career and into retirement.

A strength of this study is the large representative sample size of Irish professional flat and NH jockeys and, the comprehensive evaluation of bone density status and associated physical characteristics and lifestyle practises including dietary intake, weight making methods and racing and injury history of jockeys in Ireland. Several limitations to this study are necessary to consider when interpreting the results. Due to limited numbers of female jockeys in the overall jockey population, they were excluded from the study. The 24-hour recall provides reasonably accurate data on dietary intake of the proceeding day (18) however, due to the extreme weight cutting lifestyle of jockeys a 7-day food diary in conjunction with a photographic food recording is recommended for an accurate assessment of habitual eating patterns (17, 24). Despite this, a food diary with a photographic food recording was not logistically possible due to the size of the sample assessed and busy racing schedule. Further, while DXA is recognised as the reference method for reporting BMD and diagnosing low bone density, additional bone assessment techniques such as bone turnover markers, hormonal profile and peripheral quantitative computed tomography (pQCT) would have supported a more thorough evaluation of bone health by accounting for markers of bone metabolism, volumetric analyses including bone geometry and architecture, and bone strength using strength-strain index. However, BMAD provided a volumetric adjustment to approximate the effects of bone depth and body size.

In conclusion, this study confirms Irish jockeys continue to experience a poor level of bone density with a particularly high rate of low BMD at the LS. Flat jockeys display higher rates of low BMD compared to NH jockeys, with some presenting with very low levels of bone density. Dietary intake and estimated bone loading history were not associated with bone markers at the LS and FN. Physical factors including body mass and lean mass had a positive relationship at the LS but not FN, indicating signs of a site-specific influence of horse riding on spine bone markers. To the best of the author's knowledge, this is the first study to report where riding experience and timing of weight cut in NH jockeys and weight cutting in flat jockeys were seen to negatively influence bone density, suggesting further research is required to examine these modifiable lifestyles factors. Further, analyses found a positive association between the use of dietary supplements and the LS in flat jockeys, and this may provide a simple and practical strategy for bone loss prevention. The high-risk nature of horse racing and worrying trends of poor bone density in jockeys indicate future research is necessary to assess the long-term impact of rapid weight cycling on a career in race riding. Based on the results of this study, a bespoke industry-led bone health intervention programme is required for the long-term health and well-being of jockeys in Ireland and worldwide.

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