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Body Mass Index and Serum γ-glutamyltransferase Level as Risk Factors for Injuries Related to Professional Horse Racing: A Prospective Study

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Abstract: Body Mass Index and Serum γ-glutamyltransferase Level as Risk Factors for Injuries Related to Professional Horse Racing: A Prospective Study: Hiroko Tobari, *et al*. Department of Public Health Medicine, Doctoral Programs in Medical Sciences, Graduate School of Comprehensive Human Sciences, University of Tsukuba—Objectives: Prevention of horse-related injuries is considered difficult because horse behavior is unpredictable. Therefore, risk factors for injuries related to professional horse racing need to be investigated. We conducted a study to determine whether body mass index (BMI) and γ-glutamyltransferase (GGT) levels are associated with professional horse racing-related injuries. **Methods:** A baseline healthy survey of 546 male grooms and exercise riders aged 40–70 yr working at Miho Training Center, the largest racing-horse training facility in Japan, was performed in May 2003. A total of 93 occupational injuries occurred from June 1, 2003 to December 31, 2005. The Cox proportional hazards model was used to examine associations between the risk of injury and BMI and GGT. **Results:** Grooms and exercise riders with BMI <20 kg/m^2 or with BMI ≥25 kg/m^2 compared to BMI=20.0–22.9 kg/m^2 had 2.5 to 3.5-fold higher age-adjusted risks of injuries. The multivariate hazard ratios (95% confidence interval) after adjustment for age, GGT, smoking habit, and history of injuries were 3.5 (1.5 to 8.4) and 2.4 (1.2 to 4.8) for grooms, 3.1 (1.2 to 8.2) and 1.9 (0.4 to 10.1) for exercise riders, respectively. The age-adjusted hazard ratio of injuries for persons with GGT ≥100 IU/*l* was 2.0 to 2.5-fold higher than for those with GGT <60 IU/*l*. The multivariate hazard ratios were 1.9 (1.0 to 3.6) for grooms and 2.5 (1.0 to 6.2) for exercise riders. **Conclusions:** Low and high BMI and high GGT were associated with professional horse racing-related injuries.
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Key words: Accidents, Epidemiology, Horse riding, Physical examination, Risk factors

While the mastery of man and horse capabilities adds relish to horse riding, independent and unpredictable horse movements increase the risk of injury. Accidents and severe injury can happen not only while riding a horse but also when close to one, because an approximately 500 kg-weight thoroughbred can run at more than 65 km/h and kick with approximately 1 ton of force with a steel-shod hoof[1–3].

Well-trained professional horse racing riders who wear safety equipment are also vulnerable to injury. Preventive measures including helmets as worldwide-recommended safety tools have been advocated for riders and anyone in close contact with horses[1–12]. However, further injury prevention measures are needed[1–6]. Horse riding requires a keen sense of balance, celerity, and reasonable physical fitness[4, 5], therefore, accidents and severe injury could be related to certain conditions and the rider-related

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factors. Several studies have shown a significant association between obesity and the risk of work-related injuries[13–15], yet, it is unclear whether overweight is also associated with an increased risk of injury related to professional horse racing. A few studies have attempted to clarify whether alcohol use is a risk behavior for horse riding/handling injuries. Two case reports showed that blood alcohol concentrations were detectable among 6 of 18 decedents due to horseback-riding associated injuries[7], and 8 of 47 patients with equine-related trauma[8]. However, little is known about the relationship between γ-glutamyltransferase (GGT) as a marker of alcohol consumption[16–18] and injuries among people who ride or work with horses.

In the present study, we investigated whether body mass index (BMI) and γ-glutamyltransferase were associated with increased risk of professional horse racing-related injuries over 2.6 yr of follow-up.

Subjects and Methods

Study facility

The Miho Training Center is the largest racehorse training facility in Japan, where approximately 2,300 racehorses are stabled. Under direction of about 120 horse trainers, approximately 1,100 certified grooms for horses and 300 licensed training assistants exercise racehorses.

Grooms care for horses; mounting or drawing them for warm up and down; preparing them for training and racing, i.e., saddling up and down; assisting riders in mounting and dismounting; working for others, i.e., cleaning tack, stacking feed, and bedding; and loading horses into horse trailers for racing. Some grooms are called “grooms of training horses”, and they undertake not only care but also exercise two horses. Training assistants mount horses and train them in techniques of racing and racetrack manners; warm them up and down; and prepare them for training, i.e., mounting and dismounting. They usually exercise four to six horses everyday. Exercise riders mount for training only which differs from jockeys in that they mount for training and race riding. We divided workers based on the job category: “grooms” as grooms of non-training horses; “exercise riders” as grooms of training horses or as training assistants.

Grooms and exercise riders are required to work from 3–4 a.m. to 4–5 p.m. everyday, although they take lunch and afternoon breaks of approximately 4 to 5 h daily. Moreover, they have to accompany horses to races on weekends. They spend a long time with racehorses; therefore, it is expected that they would experience horse-related occupational injuries happen frequently.

According to a survey of industrial accident rates, the average annual injury frequency rate [number of deaths and injuries due to industrial accidents / cumulative hours worked × 1,000,000] and severity rate [aggregated number of workdays lost / cumulative hours worked × 1,000] of the Miho Training Center for 2003–2005 were 33.0 and 1.44, respectively. These data are approximately 10-fold higher than those for 2003 of the Japanese service industry, 3.75 and 0.19, respectively[19]. Therefore, the development of preventive measures is vital for the reduction of the frequency and severity of injuries.

Study population

The study subjects were 798 workers aged 40–70 yr registered at the Miho Training Center in 2003. We did not include 727 workers aged 20–39 yr, who had no data of serum GGT, because employers are not obliged to measure it under the law. We recruited all of 593 male workers aged 40–70 yr receiving an annual medical checkup in May 2003, including 464 grooms of non-training horses and 129 exercise riders (32 grooms of training horses and 97 training assistants).

The following men were excluded from the data analysis: 1) those who suffered from liver, pancreas, and active bile duct diseases (n=12); 2) those who had a history of stroke (n=6), coronary heart disease (n=8), or cancer (n=15); and 3) those who took paid leave of over six months (n=6). Consequently, 442 grooms of non-training horses, and 104 exercise riders (24 grooms of training horses and 80 training assistants) comprised the study population.

The Safety and Occupational Health Committee of Miho Training Center and the Ethics Committee of Osaka University approved this study.

Data collection

The baseline survey was performed according to the Ordinance on Industrial Safety and Health on May 2003. Subjects’ eyesight, hearing, height, and body weight were measured, and BMI was calculated as body weight in kg / (height in m)^2. BMI categories (<20.0, 20.0–22.9, 23.0–24.9 and ≥25.0 kg/m^2) were based on World Health Organization BMI cut-off points for Asian people[20, 21].

Blood pressure was measured by trained technicians using a standard mercury sphygmomanometer on the right arm in seated position after a 5-min rest. Hypertension was defined as systolic blood pressure (SBP) of ≥160 mm Hg and/or diastolic blood pressure (DBP) of ≥95 mm Hg and/or use of antihypertensive medication. Venous blood samples were taken and analyzed within 24 h of venipuncture at the All Japan Labor Welfare Foundation (Ibaraki, Japan) using an autoanalyzer (LABOSPECT-008, Hitachi High-Technologies, Japan) for the following parameters: serum GGT; aspartate aminotransferase (AST); alanine aminotransferase (ALT); total cholesterol; high density lipoprotein (HDL) cholesterol; triglycerides (TG); and non-fasting blood glucose. Serum GGT was assayed by L-γ-glutamyl-3-carboxy-4-nitroanilide by the substrate kinetic method.

Hemoglobin and red blood cell count (RBC) were analyzed using SE-9000 (Sysmex, Japan). Diabetes was defined as a serum glucose level of ≥7.8 mmol/*l* and/or use of medication for diabetes. GGT categories (<60, 60–99, and ≥100 IU/*l*) were based on the Manual for Health Check-ups under the Medical Service Law for the Aged issued by the Ministry of Health, Labour and Welfare[22]. A health survey questionnaire on current health conditions, medical history including medications for hypertension and diabetes mellitus, smoking habit (never, former, and current smokers), and alcohol consumption (never, former, and current drinkers) was conducted by trained medical doctors. Current drinkers were then asked about their frequency of drinking (≤1, 2–3, 4–6, or ≥7 per week), and the amount (≤1, 2–3, or ≥3 *go* Japanese sake) drunk on one occasion. From these data, we calculated the amount of ethanol (23.0 g ethanol corresponding to 1 *go* of Japanese sake) consumed per day, and classified alcohol consumption into four categories (never or former, ≤23.0, 23.1–68.9, and ≥69.0 g ethanol per day).

Occupational injuries and endpoints

We obtained database records of employees' applications for compensation to the Worker's Accident Compensation Insurance Benefits, which provides free medical treatment and the equivalent of 60% of the basic daily wage for non-fatal injuries with absence from work ≥4 days.

History of injuries was defined as an injury occurring from the day of the introduction of the computer database (January 1, 2000), to the day of the baseline survey finished (May 31, 2003).

We also obtained dates of hire and of termination through to the end of 2005 to determine observation periods. The observation period was truncated to the date of the first reported occupational injury, the date of separation from the job, or December 31, 2005, whichever came first.

Statistical analysis

Difference in mean values of baseline characteristics between job categories (grooms and exercise riders), and between injury statuses were tested using Student's *t*-test and either the pooled (equal variances) or Satterthwaite (unequal variances) methods for continuous independent variables. We used the Kruskal-Wallis rank test for non-normally distributed variables. The Chi-square test for independence was performed to test differences in categorical variables between job categories, and between injury statuses. We used Fisher's exact test to assess the distributions dominated by a small proportion of occupational injuries by activity, mechanism, affected body part, and diagnosis between job categories.

Cox proportional hazards models were used to calculate the hazard ratios and 95% confidence intervals (95%CI) of occupational injury. The proportional hazards assumptions were examined through a time-dependent covariate presenting the interaction between BMI and GGT categories and follow-up time, and by visual inspection of the graph. The hazards were proportional over the entire follow-up. We examined associations between the risk of occupational injuries and BMI categories and GGT categories. Adjustments for age (yr), alcohol consumption (categorical), smoking habit (categorical), and history of occupational injuries (categorical) were conducted. The analyses were implemented using SAS 9.1 software (Cary, NC). All probability values for statistical tests were two-tailed, and $p<0.05$ was regarded as statistically significant.

Results

General characteristics of grooms and exercise riders

The mean age at baseline of the 546 workers was 52.7 ± 6.8 yr, and 32% of the subjects were 40–49 yr, 49% of the subjects were 50–59 yr, 19% of the subjects were 60–70 yr. As Table 1 shows, 442 (81%) reported that they worked as grooms, and 104 (19%) as exercise riders. Exercise riders were 5.6 yr younger, and had lower body weight, BMI, SBP, DBP and hemoglobin, and were more likely to be current smokers, than the grooms. GGT, AST, total cholesterol, HDL cholesterol, triglycerides, non-fasting blood glucose, and alcohol consumption did not differ significantly between the two groups, but ALT was slightly higher among grooms than among exercise riders.

Occupational injuries of grooms and exercise riders

A total of 100 incidents occurred among the 546 workers followed for 2.6 yr, from June 1, 2003 to December 31, 2005. We excluded individuals who did not claim compensation for their injury (n=7). Ninety-three first accidents were ascertained. The injury rate per 1,000 person-years was higher among exercise riders than grooms: 140.6 vs. 63.3 (Table 2). Overall, the majority (61%) of injuries occurred while not mounted, but injury circumstances differed according to job category ($p<0.001$). For grooms, the majority of injuries (83%) were received while unmounted, with the highest injury rate (25.1 per person-years) being kicked/bitten/stepped on. In contrast, most injuries (83%) for exercise riders were received when mounted, with the highest injury rate (70.3 per person-years) being falls/rolls. Distributions of affected primary body parts and diagnosis were not statistically different between the two groups. Although activity varied according to job category, days of absence from work following the injury was not statistically different between the two job categories. The medians (interquartile range) of absent days were 31 (10–

Table 1. Baseline characteristics of grooms and exercise riders

Characteristics	Grooms (n=442) Mean (SD) or prevalence		Exercise riders (n=104) Mean (SD) or prevalence		*p*
Age, yr	53.8	(6.6)	48.2	(5.5)	<0.0001
Height, cm	164.1	(6.3)	160.3	(5.5)	<0.0001
Body weight, kg	63.9	(9.3)	55.9	(4.6)	<0.0001
BMI, kg/m^2	23.7	(3.0)	21.8	(1.9)	<0.0001
Systolic blood pressure, mmHg	132.7	(16.4)	124.9	(13.4)	<0.0001
Diastolic blood pressure, mmHg	78.9	(10.4)	73.8	(9.1)	<0.0001
GGT*, U/*l*	40	(26–68)	41	(27–71)	0.69†
GGT, U/*l*, n (%)					
<60	308	(69.7)	69	(66.3)	0.56
60–99	66	(14.9)	20	(19.2)	
≥100	68	(15.4)	15	(14.4)	
AST*, U/*l*	29	(24–34)	28	(24–33)	0.18†
ALT*, U/*l*	24	(20–33)	23	(19–28)	0.02†
Total cholesterol, mmol/*l*	5.42	(0.86)	5.27	(0.92)	0.11
HDL cholesterol, mmol/*l*	1.67	(0.45)	1.67	(0.38)	0.93
Triglycerides*, mmol/*l*	1.34	(0.88–2.00)	1.25	(0.85–2.10)	0.64†
Hemoglobin, g/d*l*	14.7	(1.0)	14.7	(1.1)	0.55
Nonfasting blood glucose*, mmol/*l*	5.28	(4.83–6.17)	5.17	(4.75–5.78)	0.06†
Alcohol consumption*§, g/day	57.5	(23.0–57.5)	57.5	(23.0–57.5)	0.19†
Alcohol consumption category, n (%)					
Never or former	124	(28.1)	23	(22.1)	0.32
≤23.0 g/day	142	(32.1)	31	(29.8)	
23.1–68.9 g/day	156	(35.3)	42	(40.4)	
≥69.0 g/day	20	(4.5)	8	(7.7)	
Smoking habit, n (%)					
Never	180	(40.7)	25	(24.0)	0.006
Former	19	(4.3)	7	(6.7)	
Current smoker	243	(55.0)	72	(69.2)	

SD, standard deviation; BMI, body mass index; GGT, γ-glutamyltransferase; AST, aspartate aminotransferase; ALT, alanine aminotransferase; HDL, high density lipoprotein. Numbers might not add up to totals because of rounding. Between job categories were tested using the Student's *t*-test and either the pooled (equal variances) or Satterthwaite (unequal variances) methods for continuous variables or the chi-square tests for categorical variables. *Values were expressed as median (interquartile range, 25–75% of its distribution). †Kruskal-Wallis rank tests were used for non-normally distributed variables. §Never or former drinkers were excluded.

80) days for grooms and 34 (10–64) for exercise riders (p=0.91).

Other factors associated with injuries

There was no significant difference between the age distribution of thoroughbreds involved and those not involved in the injuries. In this study, weather, seasons, and ground conditions were not notable triggers for injuries (data not shown).

Comparison of variables with injury statuses in each job category

Table 3 shows the baseline characteristics of injury status by job category. The proportions of grooms with low BMI (<20.0 kg/m^2) and high BMI (≥25.0 kg/m^2) were higher in injury cases than in those without. A similar trend was observed among exercise riders although the number of persons with high BMI was small. The median GGT level and the proportion of high GGT (≥100 IU/*l*) were higher in injury cases than in those without among exercise riders. A similar but weaker trend was observed among the grooms. Other factors, i.e., height, body weight, SBP, DBP, the prevalence of hypertension, serum levels of AST, ALT, total cholesterol, HDL cholesterol, TG, hemoglobin, non-fasting blood glucose, the prevalence of diabetes, alcohol consumption, smoking,

Table 2. Distributions and injury rates (per 1,000 person-years) of occupational injuries by activity, mechanism, affected body part, and diagnosis

	Grooms		Exercise riders		Total	
	No. of cases (%)	Injury rate*	No. of cases (%)	Injury rate*	No. of cases (%)	Injury rate*
Person-years	995		213		1,208	
Total	63 (100)	63.3	30 (100)	140.6	93 (100)	77.0
Activity						
Mounted						
Training	0 (0.0)	0.0	12 (40.0)	56.2	12 (12.9)	9.9
Warming up or down	8 (12.7)	8.0	6 (20.0)	28.1	14 (15.1)	11.6
Preparing for or finishing with training	3 (4.8)	3.0	7 (23.3)	32.8	10 (10.8)	8.3
Not mounted						
Caring horses	17 (27.0)	17.1	1 (3.3)	4.7	18 (19.4)	14.9
Warming up or down	17 (27.0)	17.1	1 (3.3)	4.7	18 (19.4)	14.9
Preparing for or finishing with training	10 (15.9)	10.0	1 (3.3)	4.7	11 (11.8)	9.1
Other stable works	8 (12.7)	8.0	2 (6.7)	9.4	10 (10.8)	8.3
Mechanism						
Fall/roll	17 (27.0)	17.1	15 (50.0)	70.3	32 (34.4)	26.5
Kicked/bitten/stepped on	25 (39.7)	25.1	6 (20.0)	28.1	31 (33.3)	25.7
Pushed/pulled/jerked	5 (7.9)	5.0	2 (6.7)	9.4	7 (7.5)	5.8
Twisted/braced	14 (22.2)	14.1	7 (23.3)	32.8	21 (22.6)	17.4
Others	2 (3.2)	2.0	0 (0.0)	0.0	2 (2.2)	1.7
Body part						
Head/neck	6 (9.5)	6.0	0 (0.0)	0.0	6 (6.5)	5.0
Upper trunk	18 (28.6)	18.1	8 (26.7)	37.5	26 (28.0)	21.5
Upper extremities	5 (7.9)	5.0	3 (10.0)	14.1	8 (8.6)	6.6
Lower trunk	14 (22.2)	14.1	5 (16.7)	23.4	19 (20.4)	15.7
Lower extremities	17 (27.0)	17.1	9 (30.0)	42.2	26 (28.0)	21.5
Whole body	3 (4.8)	3.0	5 (16.7)	23.4	8 (8.6)	6.6
Diagnosis						
Fracture/dislocation	15 (23.8)	15.1	9 (30.0)	42.2	24 (25.8)	19.9
Contusion/bruise	15 (23.8)	15.1	4 (13.3)	18.7	19 (20.4)	15.7
Strain/sprain	10 (15.9)	10.0	4 (13.3)	18.7	14 (15.1)	11.6
Others	4 (6.3)	4.0	3 (10.0)	14.1	7 (7.5)	5.8
Multiple sites	19 (30.2)	19.1	10 (33.3)	46.9	29 (31.2)	24.0

*Injury rates were presented the number of occupational injuries per 1,000 person-years.

Table 3. Baseline characteristics according to injury status and job category

	Grooms (n=442)			Exercise riders (n=104)		
Characteristics	Injury (n=63)	No injury (n=379)	*p*	Injury (n=30)	No injury (n=74)	*p*
BMI, kg/m^2, n (%)						
<20.0	9 (14.3)	24 (6.3)	0.003	8 (26.7)	11 (14.9)	0.17
20.0–22.9	13 (20.6)	144 (38.0)		12 (40.0)	43 (58.1)	
23.0–24.9	15 (23.8)	110 (29.0)		8 (26.7)	19 (25.7)	
≥25.0	26 (41.3)	101 (26.6)		2 (6.7)	1 (1.4)	
GGT, U/*l*, n (%)						
<60	39 (61.9)	269 (71.0)	0.23	19 (63.3)	50 (67.6)	0.04
60–99	10 (15.9)	56 (14.8)		3 (10.0)	17 (23.0)	
≥100	14 (22.2)	54 (14.2)		8 (26.7)	7 (9.5)	
History of occupational injuries, n (%)	18 (28.6)	66 (17.4)	0.04	9 (30.0)	26 (35.1)	0.62

BMI, body mass index; GGT, γ-glutamyltransferase. Numbers might not add up to totals because of rounding. The Chi-square test was performed to test differences in categorical independent variables between injury status by job category.

eyesight disorders, hearing disorders, and job experience years were not different between injury cases and those without in each job category (not shown in the table).

Associations of BMI and GGT with occupational injuries

Table 4 shows age-adjusted and multivariate hazard ratios (95%CI) of occupational injuries according to BMI, GGT and other risk factors by job category. The multivariate-adjusted hazard ratios at BMI <20.0 and ≥25.0 kg/m^2 categories were 3.5 (1.5 to 8.4) and 2.4 (1.2 to 4.8), respectively, for grooms, and 3.1 (1.2 to 8.2) and 1.9 (0.4 to 10.1), for exercise riders. For exercise riders, the relative estimate for high BMI was inconclusive because of the limited number of people with high BMI (n=3). The multivariate hazard ratios for injuries for GGT ≥100 IU/*l* compared with GGT <60 IU/*l* were 1.9 (1.0 to 3.6) for grooms, and 2.5 (1.0 to 6.2) for exercise riders. History of occupational injuries was significantly associated with risk of injuries among grooms but not among exercise riders. Age, alcohol consumption, and smoking habit were not associated with the risk of injuries among either grooms or exercise riders. The result was not changed by using other cut-off levels of alcohol consumption.

Discussion

This study showed that BMI and GGT, a marker of alcohol consumption[16–18], were independent risk factors for occupational injuries related to professional horse racing. Exercise riders with low BMI and grooms with low and high BMI appeared to be at greater risk of injuries than those with normal BMI. Our results were consistent with previous studies showing a bimodal distribution of injuries among runners[23] or military recruits[24].

Low BMI is a well-documented risk factor for work- or exercise-related low back or lower extremity injuries[25, 26]. Of the 9 injured grooms with low BMI in our study, the affected body parts were also mainly the lower trunk and lower extremities (n=3 and 4, respectively). Sakata et al. reported that those who skipped breakfast tended to take less energy and calcium than those who did not in Japan[27]. Since professional horse racing riders and stable workers are breakfast skippers, we postulate that those with low BMI could have nutritional deficiencies. Moreover, exercise riders are more likely to have nutritional deficiencies than grooms, because they tend to keep their weight around 50 kg, like jockeys. In addition, we found that exercise riders were more likely to be smokers than grooms (69% vs. 55%, $p<0.05$). It is possible that a proportion of the exercise riders who smoke consider smoking as an effective method of losing weight. However, whether improvement in nutrition and cessation of smoking prevent injuries, remains to be examined.

A high BMI, i.e., overweight or obesity, has been found to be associated with low back or low extremity injuries, probably due to the high load on musculoskeletal structures of the excess weight[13–15]. Additionally, physical movements by obese men may be less efficient leading to such individuals being at higher risk of injuries than those with normal weight in a large number of work tasks and daily activities[28]. Previous studies reported that weight loss improves balance control in obese subjects and the extent of the improvement was directly related to the amount of weight loss[29, 30]. Grooms with high BMI sustained injuries of the upper trunk, including falls/rolls (5 out of 9), while injuries in those with low or normal BMI involved the upper trunk and were related to being kicked, bitten, or stepped on (8 out of 9) or pushed (1 out of 9) by the horses (data not shown). These injuries may be due to body imbalance and reasonable physical fitness may lead to avoidance of such injuries.

We found an association between high GGT (≥100 IU/*l*) and risk of occupational injuries among both grooms and exercise riders. This association was independent of BMI, smoking habit, and history of occupational injuries. This result was consistent with a previous study. Swedish male residents with high GGT (>80 IU/*l*) had history of fractures 4–6 times, and surgeon consultations 6–13 times more often than those with low GGT (<20 IU/*l*)[31].

Positive history of occupational injuries was associated with increased risk of injuries in grooms, but not in exercise riders. Grooms spend more time with horses than exercise riders, therefore, they are more likely to suffer repeated injuries. A previous study showed that more than one-third of injured equestrians reported more than one accident experienced in the past[32]. On the other hand, exercise riders spend less time with horses than grooms, and those who suffered fall/roll-related injuries may have learnt from experience how to avoid a second injury. Age was not significantly associated with the risk of injuries in this study, which may suggest that experience can compensate for aging deficit, e.g., declining physical strength and balance.

Our study has several limitations. First, alcohol consumption was estimated based on questionnaires. Though it did correlate positively with high levels of GGT (Spearman rank correlation coefficients, r=0.51, $p<0.0001$), it was not associated with risk of injuries. This may be due to a misclassification by our alcohol questionnaire, especially for binge drinkers. Binge drinkers were reported to have higher serum GGT levels than non-binge drinkers[33] and binge-drinking was a sensitive marker of injuries[34, 35]. Second, grooms and exercise riders aged less than 40 yr were not examined in the present study, but may be worthy of a further study, because they account for a significant proportion of the work population. Third, we had no information on psychosocial human[36] and horse factors[37], in particular, the rearing method[38]. However, since only well-reared thoroughbreds were registered at the Miho Training

Table 4. Hazard ratios (HR) of occupational injuries according to BMI, GGT, and other risk factors for grooms and exercise riders

	Grooms						Exercise riders					
	No.	Person-years	No. of cases	Age-adjusted HR (95%CI)	Multivariate HR† (95%CI)	Multivariate HR‡ (95%CI)	No.	Person-years	No. of cases	Age-adjusted HR (95%CI)	Multivariate HR† (95%CI)	Multivariate HR‡ (95%CI)
Per 1-SD change in age*	442	995	63	1.3 (1.0–1.7)	1.3 (1.0–1.7)	1.2 (0.9–1.6)	104	213	30	1.1 (0.8–1.5)	1.2 (0.8–1.7)	1.1 (0.8–1.7)
BMI, kg/m^2												
<20.0	33	70	9	3.5 (1.5–8.1)	3.5 (1.5–8.4)	3.5 (1.5–8.4)	19	32	8	2.5 (1.0–6.0)	3.1 (1.2–8.2)	3.0 (1.1–7.9)
20.0–22.9	157	354	13	1.0	1.0	1.0	55	123	12	1.0	1.0	1.0
23.0–24.9	125	287	15	1.4 (0.7–2.9)	1.4 (0.7–2.9)	1.4 (0.7–3.0)	27	54	8	1.5 (0.6–3.7)	1.2 (0.5–3.0)	1.5 (0.6–3.8)
≥25.0	127	283	26	2.4 (1.2–4.7)	2.4 (1.2–4.8)	2.6 (1.3–5.1)	3	5	2	3.8 (0.9–17.4)	1.9 (0.4–10.1)	3.7 (0.7–18.6)
GGT, U/*l*												
<60	308	699	39	1.0	1.0	–	69	143	19	1.0	1.0	–
60–99	66	147	10	1.3 (0.6–2.6)	1.4 (0.7–2.9)	–	20	47	3	0.5 (0.1–1.6)	0.4 (0.1–1.5)	–
≥100	68	149	14	1.9 (1.0–3.6)	1.9 (1.0–3.6)	–	15	24	8	2.3 (1.0–5.3)	2.5 (1.0–6.2)	–
Alcohol consumption, g/day												
Never or former	124	279	19	1.0	–	1.0	23	51	5	1.0	–	1.0
≤23.0	142	324	17	0.8 (0.4–1.6)	–	1.0 (0.5–2.0)	31	59	10	1.7 (0.6–5.1)	–	2.3 (0.8–6.8)
23.1–68.9	156	346	22	1.0 (0.5–1.9)	–	1.2 (0.7–2.4)	42	87	13	1.6 (0.6–4.4)	–	1.6 (0.6–4.8)
≥69.0	20	47	5	1.7 (0.6–4.5)	–	1.8 (0.7–4.9)	8	17	2	1.3 (0.3–6.7)	–	2.3 (0.4–13.0)
Smoking habit												
Never	180	411	20	1.0	1.0	1.0	25	47	8	1.0	1.0	1.0
Former	19	40	4	2.0 (0.7–5.9)	1.7 (0.6–5.2)	1.6 (0.5–5.0)	7	17	1	0.4 (0.1–2.9)	0.6 (0.1–5.0)	0.4 (0.1–3.5)
Current smoker	243	543	39	1.5 (0.9–2.7)	1.5 (0.9–2.6)	1.5 (0.9–2.6)	72	149	21	0.9 (0.4–2.1)	0.8 (0.3–2.1)	0.9 (0.3–2.2)
History of occupational injuries												
No	358	823	45	1.0	1.0	1.0	69	139	21	1.0	1.0	1.0
Yes	84	172	18	1.8 (1.0–3.2)	2.1 (1.2–3.6)	2.0 (1.1–3.6)	35	75	9	0.8 (0.4–1.7)	0.5 (0.2–1.3)	0.7 (0.3–1.5)

BMI, body mass index; GGT, γ-glutamyltransferase. *1-SD change in age: 6.7 (grooms) and 5.5 (exercise riders). †Multivariate: adjusted for age, body mass index (4 categories), smoking habit (3 categories), history of occupational injuries (yes or no), and GGT (3 categories), except for the variable of interest. ‡Multivariate: adjusted for age, body mass index (4 categories), smoking habit (3 categories), history of occupational injuries (yes or no), and alcohol consumption (4 categories), except for the variable of interest.

Center, the impact of the horse factor may be small.

In conclusion, the present study shows that high and low BMI and high GGT were associated with increased risk of occupational injuries among Japanese middle-aged grooms and exercise riders. Health promotion activities targeting weight maintenance and modification of alcohol consumption could help reduce the risk of injuries.

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