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Factors associated with lower limb tendinopathy in a large cohort of runners: a survey with a particular focus on nutrition

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ABSTRACT

Objectives Lower limb tendinopathy (LLT) is highly prevalent in runners. Treatment can be challenging, and knowledge of risk factors may be valuable to develop preventive or treatment interventions for LLT. The aims of this study were (1) to assess the prevalence of three common LLTs (Achilles tendinopathy (AT), patellar tendinopathy and plantar fasciopathy) in a large cohort of Dutch and Belgian runners and (2) to investigate its association with potential risk factors, with a particular focus on nutritional factors in the habitual diet.

Methods A total of 1993 runners were included in the study. They completed two online questionnaires: a general questionnaire on running habits and injuries and a Food Frequency Questionnaire. Runners with and without LLT were compared regarding personal characteristics, running characteristics and nutritional factors.

Results The point prevalence for the three LLTs was 6%; 33% of the runners reported LLT in the past and 35% had either a current or past LLT. AT was the most prevalent type of LLT, and prevalence rates for all types of LLT were higher in men than women. Positive associations with LLT were observed for age and running years (men and women), running level and running distance (men). No associations between LLT and nutritional factors were observed.

Conclusion One-third of this population of runners had ever experienced an LLT. These tendinopathies were associated with gender, age and running load, but not with nutritional factors.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Lower limb tendinopathy (LLT) is highly prevalent in runners and has a multifactorial aetiology.
⇒ Preclinical and animal studies have shown that various nutrients can play a role in (mal)adaptation and repair of tendons. However, knowledge of the role of nutrition, and especially habitual dietary intake, in human tendon health is scarce.

WHAT THIS STUDY ADDS

⇒ This study confirms that LLT is common in runners and that running load is an associated factor.
⇒ LLT was not associated with habitual dietary intake in our population of runners with a relatively high diet quality.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Future prospective studies in (novice) runners with an average or low diet quality could provide more insight into the relationship between nutrition and the development of LLT.

INTRODUCTION

Tendinopathy is persistent tendon pain and loss of function related to mechanical loading.[1] Lower limb tendinopathy (LLT) is highly prevalent in runners. Common types of LLT in runners are Achilles tendinopathy (AT), patellar tendinopathy (PT) and plantar fasciopathy (PF).[2] Prevalence rates vary between studies because of different definitions and study populations used. In a review on the prevalence of running-related injuries, prevalence rates of 6.2%–9.5% were found for AT, 12.5% for PT and 5.2%–17.5% for PF.[2] Tendinopathy may negatively affect the quality of life by its impact on activities of daily living, health, sports performance, workability and other activities.[3 4] Treatment of LLT can be challenging, is not completely evidence-based and should at least include load management, pain education and progressive tendon loading exercises.[5 6]

LLT is considered to have a multifactorial aetiology with mechanical overload as an important risk factor. Besides mechanical overload, sex, age, body weight, medical conditions such as obesity and diabetes as well as genetic factors are also associated with tendinopathy.[7–9] More knowledge of risk factors may be valuable to develop preventive or treatment interventions for LLT.

Tendinopathy is characterised by altered tissue homoeostasis.[10] Nutrition plays a major role in tendon homoeostasis; and adequate nutrient intake is essential for recovery and maintaining homoeostasis. Nutritional interventions may, therefore, be useful for the prevention or treatment of LLT. Preclinical and animal studies have shown that various nutrients such as collagen, proteins, specific amino acids (leucine, arginine, glutamine), vitamins C and D, manganese, copper and zinc can play a role in (mal)adaptation and repair of tendons.[11 12] However, knowledge of the role of nutrition, especially habitual dietary intake, in human tendon health is scarce. More research on this topic is necessary to investigate the potential benefits of nutritional interventions.[13]

The aims of this study are (1) to assess the prevalence of three common LLTs (AT, PT and PF) in a large cohort of runners and (2) to investigate its association with potential risk factors, with a particular focus on nutritional factors in the habitual diet.

METHODS

Study design

The Eat2Run study is an observational study with a cross-sectional design. Participants were runners who completed two online questionnaires: a general questionnaire and a Food Frequency Questionnaire (FFQ). The general questionnaire contained questions about gender, age, anthropometric data, running habits, current and past injuries, abdominal complaints, and general health issues. The FFQ was used to assess habitual dietary intake.

Study population

In July 2021, recruitment of runners started by requesting athletics clubs and running event organisations in the Netherlands and Belgium, among which the popular Dutch Seven Hills run in Nijmegen, to help with the recruitment by posting a news item in their newsletter or on their website. In the second stage, social media (Facebook, Twitter, Linkedin) were also used for recruitment. Finally, in March 2022, participants of the 2022 edition of the well-known Rotterdam Marathon who indicated a willingness to participate in scientific studies, were invited. When the recruitment period closed on 1 June 2022, 3643 runners had expressed interest for the study, although not all fulfilled the inclusion criteria.

To be included in the present analyses, runners (1) had to be at least 18 years old, (2) had to run at least once a week in the past year, no matter the time or distance, or would usually run at least once a week if they had not been injured, (3) had to complete both the general questionnaire and the FFQ and (4) their reported habitual dietary intake in the FFQ had to be plausible (see the paragraph on Assessment of dietary intake and diet quality). Finally, 1993 runners could be included in the data analyses (see the Results section).

Assessment of tendinopathy

Information on current or past injuries was obtained from the general questionnaire. An injury was defined according to the International Olympic Committee consensus statement: 'Injury is tissue damage or other derangement of normal physical function due to participation in sports, resulting from rapid or repetitive transfer of kinetic energy'.[14] The presence of current or past running-related AT, PT and PF was identified when this definition could be applied to specified locations on the heel, knee and foot, respectively, on standardised pain maps included in the questionnaire.

Runners with current LLT were asked to rate its severity. For this purpose, the Victorian Institute of Sport Assessment-Achilles tendon questionnaire (VISA-A),[15 16] the Victorian Institute of Sport Assessment-Patellar tendon questionnaire (VISA-P)[17 18] and the Foot Function Index with Verbal Rating Scales questionnaire (FFI-5pt)[19] were included in the general questionnaire. The VISA-A and VISA-P questionnaires contain eight questions for rating pain, function and sports participation. The total scores range from 0 (worst) to 100 points. The FFI-5pt consists of 23 items. The FFI score is total points/230×100%, with 100% being the worst.

Assessment of dietary intake and diet quality

The FFQ was used to assess dietary intake over the past month. A comprehensive FFQ, validated for energy intake, macronutrients, dietary fibre and vitamins, was used to assess the frequency of consumption of 180 food items.[20 21] Portion sizes were estimated using natural portions and commonly used household measures. From the FFQ data, the average daily intake of foods and food groups was calculated. Data were also converted into average daily energy and nutrient intake using the Dutch food composition database of 2011.[22] Runners reporting an implausible habitual dietary intake, that is, energy intake <800 and >4200 kcal for men and <500 and >3500 kcal for women,[23 24] were excluded from the analyses.

In addition to absolute energy and nutrient intake, diet quality was also assessed. For this purpose, the Dutch Healthy Diet index 2015 (DHD2015-index)[25] was calculated from FFQ data. The DHD2015-index is a measure of adherence to the 2015 Dutch dietary guidelines.[26 27] The original index consists of 15 components; recently a component on unhealthy foods has been added.[28] For all the components, a score is assigned based on the intake of the specific food group, ranging from 0 to 10 points (online supplemental table 1). This results in a total DHD2015-index score ranging from 0 to 160 points, with a higher score indicating better adherence to the guidelines. From the FFQ used in the current study, data on two components (coffee and salt) were unavailable, which were therefore not included in the DHD2015-index calculations. This results in total scores ranging from 0 to 140 points in the current study. A more detailed description of the DHD2015-index and scoring per component can be found elsewhere.[25]

Statistical analyses

Continuous data were first checked for normality using a Kolmogorov-Smirnov test and visual inspection of Q-Q normality plots. After that, descriptive analyses were performed. Personal characteristics, running characteristics, nutritional factors and prevalence of AT, PT and PF were examined in the total population and per gender. As the continuous data were not normally distributed, these data are presented as median (25–75th percentile); categorical variables are presented as n (%).

Differences between men and women were assessed using a Mann-Whitney U test for continuous variables and a Pearson χ^2 test for categorical variables. Gender-neutral runners and runners who did not fill in their gender were not compared with other groups because these groups were too small.

Next, runners with any of the three common LLTs were compared with runners without any of these LLTs. Differences between these two groups in personal characteristics, running characteristics and nutritional factors were assessed using a Mann-Whitney U test for continuous variables and a Pearson χ^2 test for categorical variables. No distinction was made between current or past LLT because the absolute number of runners with current tendinopathy was quite low. Analyses were performed separately for men and women.

The significance level for the above-mentioned statistical tests was set at 5%, that is, $p<0.05$.

Finally, associations between LLT and potential risk factors were investigated using logistic regression analysis. This analysis was performed in the total population. Prevalence of any of the three common LLTs, present or past (yes/no), was used as a dichotomous dependent variable. Personal characteristics, including gender and running characteristics that differed between runners with and without LLT in the total population ($p<0.20$), and the total DHD2015-index score, were used as independent variables. The linearity of continuous independent variables and log-odds of LLT prevalence was assessed using the Box-Tidwell procedure. In case of non-linearity, the independent variable was converted into a categorical variable. A full multivariable model was fitted using data from runners without missing values (n=1967) to estimate ORs with 95% CIs for the independent variables. A backward stepwise selection procedure was used to select the strongest risk factors. The selection was based on Akaike's information criterion, corresponding to a p value of 0.157 for a predictor with one regression coefficient.[29]

Statistical analyses were performed with SPSS software (V.25, IBM).

RESULTS

Study population

A total of 3643 runners expressed their interest for the study. From these, 2118 runners completed both questionnaires. Five runners were excluded because they were younger than 18 years or did not report their age. Sixty-nine runners were excluded because they did not run, or would not have run if not injured, at least once a week in the past year. Finally, 51 runners were excluded because they reported implausible dietary intake. A total of 1993 runners (891 men, 1095 women, 5 gender-neutral, 2 who did not fill in their gender) were included in the study.

The median (25–75th percentile) age for the total population was 44 (34–54) years. The running level of most runners (76%) was considered intermediate, and about half of the runners (49%) ran for at least 10 years. The median number of running sessions per week was 3 (2–4), and the median distance covered per week was 30 (20–42) km. Compared with women, men had been running for more years, ran more often and more kilometres per week, and trained at a higher intensity. A more detailed overview of personal and running characteristics is presented in online supplemental table 2.

The median energy intake in the total population was 2095 (1700–2538) kcal. Besides vitamin C, energy

Table 1 Prevalence of tendinopathy

	Total (n=1993)*	Men (n=891)	Women (n=1095)	P value men vs women†
Current lower limb tendinopathy‡	116 (6)	68 (8)	48 (4)	**0.002**
Current Achilles tendinopathy	63 (3)	38 (4)	25 (2)	**0.012**
Current patellar tendinopathy	31 (2)	20 (2)	11 (1)	**0.027**
Current plantar fasciopathy	25 (1)	10 (1)	15 (1)	0.623
Past lower limb tendinopathy‡	664 (33)	344 (39)	318 (29)	**<0.001**
Past Achilles tendinopathy	383 (19)	219 (25)	163 (15)	**<0.001**
Past patellar tendinopathy	240 (12)	124 (14)	116 (11)	**0.024**
Past plantar fasciopathy	152 (8)	66 (7)	85 (8)	0.766
Current or past lower limb tendinopathy‡	691 (35)	361 (41)	328 (30)	**<0.001**

Data are presented as n (%).
*The total population includes five gender-neutral runners and two runners who did not fill in their gender.
†P values were obtained with a Pearson $\chi 2$ test; statistical significance ($p<0.05$) is indicated in bold.
‡Either Achilles tendinopathy, patellar tendinopathy and/or plantar fasciopathy. The prevalence of any injuries is unequal to the sum of the prevalence of the separate injuries because some runners had more than one injury, currently and/or in the past.

Table 2 Personal characteristics and running characteristics in runners with and without current or past tendinopathy

	Men (n=891)			Women (n=1095)		
	No LLT (n=530)	LLT (n=361)	P value*	No LLT (n=767)	LLT (n=328)	P value*
Age, years	45 (36–56)	51 (40–58)	**<0.001**	41 (31–51)	47 (34–54)	**<0.001**
BMI, kg/m^2	23.0 (21.5–24.5)	22.7 (21.5–24.3)	0.343	21.6 (20.2–23.3)	21.9 (20.2–23.7)	0.171
Running level			**0.026**			0.701
Beginner	13 (3)	3 (1)		28 (4)	9 (3)	
Intermediate, not competitive	381 (72)	237 (66)		624 (81)	266 (81)	
Competitive (in age group)	133 (25)	117 (32)		110 (14)	52 (16)	
(Semi)professional	3 (1)	4 (1)		5 (1)	1 (0)	
Running years			**<0.001**			**<0.001**
< 1 year	10 (2)	2 (1)		23 (3)	6 (2)	
1–2 years	49 (9)	13 (4)		77 (10)	16 (5)	
3–5 years	102 (19)	51 (14)		176 (23)	63 (19)	
6–9 years	111 (21)	69 (19)		178 (23)	60 (18)	
≥ 10 years	256 (48)	225 (62)		313 (41)	183 (56)	
Running, times/week	3.0 (2.0–4.0)	3.0 (3.0–4.0)	0.196	3.0 (2.0–3.0)	3.0 (2.0–3.0)	0.948
Running, km/week	30 (22–48)	35 (25–50)	**0.047**	25 (17–40)	25 (18–40)	0.990
Longest distance per week (km)	16 (12–21)	16 (12–20)	0.943	12 (10–17)	12 (10–16)	0.848
Intensity most intensive training			0.213			0.531
Moderately intensive	127 (24)	70 (19)		212 (28)	81 (25)	
Moderately intensive	261 (49)	181 (50)		395 (52)	180 (55)	
Moderately intensive	142 (27)	110 (31)		160 (21)	67 (20)	
Running in competitions (yes)	415 (78)	319 (88)	**<0.001**	156 (20)	273 (83)	0.170
Km on current shoes	500 (250–700)	500 (200–700)	0.700	400 (200–643)	450 (200–689)	0.585
Main surface			0.305			**0.027**
Running track	2 (0)	6 (2)		10 (1)	5 (2)	
Hard surface	326 (62)	209 (58)		453 (59)	162 (49)	
Soft surface	36 (7)	27 (8)		68 (9)	43 (13)	
Treadmill	2 (0)	1 (0)		2 (0)	0 (0)	
Various	164 (31)	118 (33)		234 (31)	118 (36)	
Warming up (yes)	322 (61)	247 (68)	0.050	472 (62)	221 (67)	0.156
Other sports besides running in past year (yes)	277 (52)	182 (50)	0.837	503 (66)	235 (72)	0.050
Other sports besides running (hours per week)	3.0 (2.0–5.0)	3.0 (2.0–5.0)	0.121	3.0 (2.0–5.0)	3.0 (2.0–4.0)	0.136

Data are presented as median (25–75th percentile) for continuous variables, and n (%) for categorical variables.
*P values were obtained with a Mann-Whitney U test for continuous variables and a Pearson χ^2 test for categorical variables; statistical significance ($p<0.05$) is indicated in bold.
BMI, body mass index; LLT, lower limb tendinopathy.

intake, and the intake of macronutrients and micronutrients were higher in men than women. When expressed as energy percentage (En%), intake of carbohydrates, fat and protein were comparable for men and women (online supplemental table 3). Diet quality (the total DHD2015-index score) was higher in women than men: median (25–75th percentile): 96.3 (85.0–106.3) vs 88.7 (77.1–100.2). Women scored higher on most component scores, except for wholegrain products, on which men scored higher (online supplemental table 4).

Prevalence of LLT

A total of 116 runners (6%) had current LLT; 3% AT, 2% PT and 1% PF. Past LLT was reported by 664 runners (33%); 19% AT, 12% PT and 8% PF. In total, 691 runners (35%) reported either having current or past LLT or

Table 3 Daily energy and nutrient intake in runners with and without current or past tendinopathy

	Men (n=891)			Women (n=1095)		
	No LLT (n=530)	LLT (n=361)	P value*	No LLT (n=767)	LLT (n=328)	P value*
Energy (kcal)	2373 (1950–2775)	2347 (1971–2875)	0.797	1901 (1580–2251)	1853 (1525–2304)	0.698
Total carbohydrates						
(g)	260 (211–310)	257 (209–317)	0.900	209 (170–250)	206 (168–253)	0.905
(En%)	44 (41–47)	44 (41–47)	0.377	44 (41–48)	44 (41–48)	0.323
Monosaccharides and disaccharides (g)	103 (81–127)	104 (78–129)	0.777	94 (74–115)	96 (76–117)	0.362
Polysaccharides (g)	155 (124–191)	154 (121–186)	0.585	113 (87–142)	115 (85–142)	0.871
Total fat						
(g)	92 (73–114)	95 (74–116)	0.616	75 (58–92)	76 (59–97)	0.232
(En%)	36 (32–39)	36 (32–39)	0.664	36 (32–39)	37 (33–40)	0.148
Saturated fatty acids (g)	31 (24–38)	31 (23–40)	0.911	25 (19–31)	25 (19–35)	0.242
Monounsaturated fatty acids (g)	33 (26–42)	35 (27–42)	0.447	28 (21–35)	28 (23–36)	0.267
Polyunsaturated fatty acids (g)	20 (15–25)	20 (15–25)	0.997	15 (11–20)	15 (12–20)	0.638
Alpha-linoleic acid (g)	1.95 (1.53–2.50)	1.96 (1.47–2.56)	0.555	1.61 (1.24–2.02)	1.58 (1.25–2.09)	0.539
Eicosapentaenoic acid (g)	0.08 (0.04–0.13)	0.08 (0.5–0.14)	0.633	0.08 (0.03–0.14)	0.09 (0.04–0.13)	0.331
Docosahexaenoic acid (g)	0.10 (0.04–0.17)	0.10 (0.05–0.17)	0.616	0.10 (0.02–0.18)	0.12 (0.04–0.17)	0.574
Cholesterol (mg)	218 (158–295)	217 (155–298)	0.963	182 (126–249)	183 (134–241)	0.947
Total protein						
(g)	86 (72–102)	87 (73–103)	0.349	70 (57–83)	70 (56–85)	0.955
(En%)	14 (13–16)	15 (13–16)	0.110	15 (13–16)	15 (13–16)	0.721
Vegetable protein (g)	44 (35–55)	43 (35–55)	0.943	36 (27–43)	34 (27–43)	0.832
Animal protein (g)	41 (31–52)	41 (31–54)	0.533	35 (25–45)	35 (25–45)	0.796
Alcohol (g)	6 (2-13)	6 (1-13)	0.660	3 (0–8)	3 (0–8)	0.672
Fibre (g)	29 (22–36)	28 (23–35)	0.861	24 (19–30)	24 (19–30)	0.945
Retinol (µg)	467 (296–670)	475 (311–700)	0.605	325 (213–469)	319 (213–465)	0.806
Retinol equivalents (µg)	843 (611–1170)	848 (607–1136)	0.870	785 (587–1039)	812 (550–1058)	0.611
Vitamin B_1 (mg)	1.1 (0.9–1.3)	1.1 (0.9–1.3)	0.444	0.9 (0.7–1.0)	0.9 (0.7–1.1)	0.438
Vitamin B_2 (mg)	1.6 (1.3–2.0)	1.6 (1.3–2.0)	0.495	1.3 (1.1–1.6)	1.3 (1.1–1.7)	0.294
Vitamin B_6 (mg)	1.8 (1.4–2.2)	1.8 (1.5–2.1)	0.753	1.5 (1.2–1.8)	1.5 (1.2–1.8)	0.842
Folate (present in food by nature) (µg)	275 (222–340)	277 (223–340)	0.919	261 (209–316)	256 (213–317)	0.960
Folate equivalents (µg)	300 (239–384)	296 (238–379)	0.835	279 (223–342)	275 (227–343)	0.943
Vitamin B_{12} (µg)	4.2 (3.2–5.7)	4.3 (3.0–5.9)	0.746	3.6 (2.5–4.9)	3.7 (2.6–5.2)	0.461
Vitamin C (mg)	89 (62–121)	87 (65–117)	0.678	93 (72–120)	95 (75–123)	0.301
Vitamin D (µg)	3.1 (2.2–4.5)	3.3 (2.2–4.4)	0.878	2.4 (1.7–3.4)	2.4 (1.6–3.1)	0.493
Vitamin E (mg)	15 (12–20)	15 (12–19)	0.483	13 (10–16)	13 (10–16)	0.893
Calcium (mg)	1007 (798–1303)	1088 (810–1324)	0.164	923 (734–1173)	977 (723–1214)	0.221
Total iron (mg)	13 (11–16)	13 (11–16)	0.544	11 (9–13)	11 (9–13)	0.735
Haem iron (mg)	0.8 (0.5–1.2)	0.8 (0.5–1.2)	0.709	0.6 (0.2–1.0)	0.6 (0.3–1.1)	0.965
Non-haemiron (mg)	12 (10–15)	12 (10–15)	0.578	11 (9–13)	10 (9–13)	0.970
Magnesium (mg)	429 (348–512)	432 (355–524)	0.659	362 (292–435)	356 (293–435)	0.878
Zinc (mg)	11 (9–14)	12 (10–14)	0.448	9 (8-11)	9 (8-12)	0.585
Selenium (µg)	47 (39–57)	49 (40–57)	0.548	40 (32–48)	40 (33–49)	0.631

Data are presented as median (25–75th percentile).
*P values were obtained with a Mann-Whitney U test.
LLT, lower limb tendinopathy.

Table 4 DHD2015-index score and its component scores in runners with and without current or past tendinopathy

	Men (n=891)			Women (n=1095)		
	No LLT (n=530)	LLT (n=361)	P value*	No LLT (n=767)	LLT (n=328)	P value*
DHD2015-index total score	88.6 (76.6–99.7)	89.0 (77.7–100.9)	0.337	96.0 (84.5–105.6)	97.6 (86.4–107.3)	0.053
DHD2015-index component scores						
1. Vegetables	6.8 (3.8–10.0)	6.8 (4.1–10.0)	0.904	9.1 (5.8–10.0)	9.9 (6.1–10.0)	0.224
2. Fruit	10.0 (5.1–10.0)	10.0 (4.9–10.0)	0.990	10.0 (6.4–10.0)	10.0 (6.3–10.0)	0.683
3a. Wholegrain products intake	5.0 (4.8–5.0)	5.0 (5.0–5.0)	0.538	4.8 (2.4–5.0)	4.3 (2.2–5.0)	0.124
3b. Ratio of wholegrain/refined grains	5.0 (2.6–5.0)	5.0 (3.0–5.0)	0.432	5.0 (3.2–5.0)	5.0 (3.4–5.0)	0.593
3. Wholegrain products total†	10.0 (7.0–10.0)	10.0 (7.3–10.0)	0.428	8.9 (6.2–10.0)	8.7 (6.2–10.0)	0.592
4. Legumes	10.0 (5.5–10.0)	10.0 (6.4–10.0)	0.878	10.0 (4.9–10.0)	10.0 (7.3–10.0)	**0.042**
5. Nuts	7.9 (2.6–10.0)	8.8 (3.2–10.0)	0.175	7.7 (2.5–10.0)	9.0 (3.8–10.0)	**0.012**
6. Dairy	6.6 (3.4–9.4)	6.8 (2.9–9.8)	0.698	5.8 (2.7–8.9)	6.4 (3.0–9.3)	0.151
7. Fish	6.3 (2.7–9.9)	6.3 (2.9–10.0)	0.478	6.4 (1.8–10.0)	7.0 (2.9–9.9)	0.279
8. Tea	1.8 (0.0–7.4)	2.6 (0.1–7.6)	**0.045**	6.5 (1.6–10.0)	6.5 (0.9–10.0)	0.312
9. Fats and oils	10.0 (1.8–10.0)	10.0 (1.8–10.0)	0.588	10.0 (1.7–10.0)	10.0 (1.3–10.0)	0.691
11. Red meat	10.0 (7.5–10.0)	10.0 (6.9–10.0)	0.387	10.0 (8.6–10.0)	10.0 (8.6–10.0)	0.587
12. Processed meat	4.9 (0.7–8.0)	5.4 (1.3–8.4)	0.166	7.4 (4.2–9.7)	7.7 (5.1–9.7)	0.449
13. Sweetened beverages and fruit juices	7.6 (3.4–9.4)	7.9 (3.7–9.4)	0.432	9.0 (7.0–9.9)	9.0 (6.5–10.0)	0.837
14. Alcohol	10.0 (8.7–10.0)	10.0 (8.6–10.0)	0.800	10.0 (10.0–10.0)	10.0 (10.0–10.0)	0.966
16. Unhealthy choices	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.965	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.620

Data are presented as median (25–75th percentile).
Component 10 (coffee) and 15 (salt) could not be calculated from FFQ data.
*P values were obtained with a Mann-Whitney U test; statistical significance (p<0.05) is indicated in bold.
†Sum score of components 3a and 3b.
DHD2015-index, Dutch Healthy Diet index 2015 ; FFQ, Food Frequency Questionnaire; LLT, lower limb tendinopathy.

both. For all types of tendinopathy, currently or in the past, prevalence rates were significantly higher in men than women (table 1).

The VISA-A. VISA-P and FFI questionnaires were completed by 55 runners with current AT, 26 with current PT and 23 with current PF. The median (25–75th percentile) score for the VISA-A was 44 (39–51), for the VISA-P 46 (40–54) and for the FFI 18 (13–25).

Association of population characteristics and nutritional factors with LLT

In both men and women, runners with LLT were older and had been running for more years than runners without LLT. In men only, runners with LLT were more competitive, ran more kilometres per week and ran more often in competitions. In women only, runners with LLT ran less often on a hard surface and more often on other surfaces than runners without LLT (table 2).

No energy and nutrient intake differences were observed between runners with and without LLT. When we corrected energy and nutrient intake for body weight, also no differences in intake between participants with and without LLT were observed (table 3).

The DHD2015-index score was not different between runners with and without LLT. Regarding component scores, women with LLT scored higher on legumes and nuts than women without LLT, and men with LLT scored higher on tea than men without LLT (table 4).

Results of the logistic regression analyses showed that gender, age, running years, the intensity of most intensive training and warming up were retained in the multivariable model. The Nagelkerke R^2 of the multivariable model was low: 0.061 (table 5).

DISCUSSION

We aimed to assess the prevalence of three common LLTs (AT, PT and PF) in a large cohort of runners and to investigate its association with potential risk factors, particularly nutritional factors in the habitual diet. The point prevalence of all three LLTs was rather low (6%), although one-third had ever experienced LLT. AT was the most prevalent type of LLT, and prevalence rates for all types of LLT were higher in men than women. In both men and women, age and running years were positively associated with LLT. In addition, in men running level, weekly running distance and running in competitions

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Table 5 Multivariable associations between risk factors and tendinopathy

	OR (95% CI)*	P value†
Gender, women vs men	0.69 (0.57 to 0.84)	<0.001
Age, years	1.01 (1.00 to 1.02)	0.016
Running years		<0.001
1–2 years vs <1 year	0.92 (0.38 to 2.21)	0.849
3–5 years vs <1 year	1.62 (0.72 to 3.64)	0.243
6–9 years vs <1 year	1.67 (0.74 to 3.74)	0.214
≥ 10 years vs <1 year	2.45 (1.10 to 5.43)	0.028
Intensity most intensive training		0.102
Intensive vs moderately intensive	1.24 (0.98 to 1.58)	0.076
Very intensive vs moderately intensive	1.34 (1.01 to 1.78)	0.043
Warming up, no vs yes	0.78 (0.64 to 0.96)	0.018

*OR=exp (beta). A value <1 indicates a decreased risk and a value >1 indicates an increased risk.
†The selection of risk factors in the multivariable logistic regression model was based on Akaike's information criterion (AIC), corresponding to a p value of 0.157 for a predictor with one regression coefficient.[29]

were positively associated with LLT, while in women running on a hard surface was negatively associated with LLT. No associations between nutritional factors and LLT were observed in this population of runners with a relatively high diet quality.

Compared with other studies, the point prevalence in the current study was low (6%). Prevalence rates of 6.2%–9.5% are reported for AT only, 12.5% for PT and 5.2%–17.5% for PF.[2] Also, the percentage of runners that had ever experienced LLT was rather low (35%) in the current study. One other study showed that former elite runners have a 52% chance of acquiring Achilles tendon injuries in their lifetime.[30] Our recruitment of runners via running event organisations could have caused this low prevalence to some extent. Likely, runners with LLT are not registered for a running event, although LLT may still have occurred after registration. Moreover, runners with past LLT may refrain from participation in running events to prevent the recurrence of injuries, resulting in low numbers of runners with current or past LLT in our study population.

LLT was more prevalent among men than women. The higher running load in man may partly explain this, as mechanical loading is related to LLT.[1 7] Indeed, male runners with LLT ran more kilometres a week than male runners without LLT, and in the multivariable regression model, the running intensity was positively associated with LLT. Thus, men ran more kilometres a week at a higher intensity than women, which may explain the higher LLT prevalence in men. However, when we corrected for running load factors in the multivariable regression model, and for body weight in a separate regression model, an association with gender was still observed, indicating a true gender effect that may be related to hormonal factors. The positive association with age we observed could result from decreased tendon cell regeneration and a reduction in cell density, and changes in tendon cell morphology and in tendon structure and composition, leading to reduced ability to tolerate high loads at older age.[31 32] However, one should recognise that older runners might have a longer running history, with presumably more tendon load and thus a higher chance of LLT occurrence in their running career. This could also explain the positive association between LLT and running years.

An important aim of this study was to investigate the association of LLT with nutritional factors. We did find no evidence for such an association, although preclinical and animal studies have shown that various nutrients can play a role in (mal)adaptation and repair of tendons.[11 12] Only a few studies investigated the impact of nutrition on tendon health and tendinopathy in human.[13] One earlier study investigated the effect of the habitual diet on Achilles tendon structure and found no associations between dietary parameters and tendon structure.[33] A few studies investigated the effect of alcohol. Alcohol intake was associated with an increased risk of AT[34] and rotator cuff tears.[35] However, in another study, no association was found between alcohol consumption and rotator cuff tendinitis.[36] We did not explicitly investigate an association of LLT with absolute alcohol intake, but an association with adherence to the Dutch dietary guideline on alcohol intake. It turned out that both runners with and without LLT scored high on adherence to this guideline, indicating a limited intake of only one Dutch unit alcohol per day. This is much lower than the alcohol consumption reported in previous studies in which an association between alcohol and tendon problems was found.[34 35]

Although there might be a relationship between nutritional factors and LLT, we did not find it in this study, which might be explained by the relatively high diet quality in our study population compared with the general population. For example, in the Lifelines Cohort Study,[37] which is a large cohort study among inhabitants of the northern three provinces of the Netherlands, a much lower total DHD2015-index score (which was based on the same 14 components as in the current study) was observed compared with both runners with and without LLT in our population; on average 15 points lower (unpublished data). The total DHD2015-index scores in our population are comparable to those observed in another Dutch population when, like in our study, the coffee and salt components are not included.[28] It is likely that this population also had an above-average diet quality as it contained a large proportion of highly educated participants with interest in participating in a study on nutrition and health. We can easily imagine that a physically active population of runners as ours is more health conscious and hence has an above-average diet quality, which applies to both runners with and without LLT, limiting the ability to find associations between nutritional factors and LLT. Otherwise, the impact of habitual dietary intake and nutritional factors on LLT could be limited in this population, if present, compared with other factors such as mechanical loading. Future prospective studies in (novice) runners with a lower diet quality could shed another light on the relationship between nutritional factors and the development of LLT.

Strengths and limitations

To our knowledge, this is the first study investigating the association of LLT and nutrition in runners. A strength of the study is the large study population of 1993 runners, covering a broad range in age, running load and running level. Another strength is the availability of comprehensive dietary intake data of the habitual diet, which allowed us to investigate many macronutrients and micronutrients as well as general diet quality.

Due to the nature of the study, a limitation is the self-reporting method of data collection. Although we used validated methods and questionnaires, these methods are prone to bias. A health professional did not diagnose the occurrence of tendinopathy, but runners had to indicate whether they had pain on specific locations on pain maps. Although we used a standardised pain map, this method is prone to bias. Assessment of dietary intake using an FFQ is prone to several types of error such as recall bias or the tendency to provide socially desirable answers.[38] Moreover, an FFQ is not the best method to assess absolute dietary intake. In addition, nutrient intake from supplements could not be assessed. However, an FFQ is a reliable method to rank participants to their intake levels,[20 21] and in epidemiological studies on associations of dietary intake with diseases, such as LLT, the ranking of participants according to their intake levels is more relevant than absolute levels of intake.

The absolute number of runners with current tendinopathy was quite low, which is too low to investigate many potential associations. Therefore, we decided to include also runners with past tendinopathy in the 'LLT group' for comparison with the 'no (never) LLT group'. For runners with past tendinopathy, it could have been that changes in dietary intake and/or running characteristics had occurred between the period that tendinopathy was present and the current time, which may or may not be a consequence of the injury. This could introduce reversed causation, for example, in the LLT group fewer runners ran predominantly on a hard surface compared with the no LLT group. It may be that runners started to run more often on soft surfaces after injury to prevent future injuries. Regarding dietary intake, stable food consumption patterns over time can be assumed.[39] However, data collection took place during the COVID-19 pandemic, and studies have shown that the lockdown due to this pandemic resulted in changes in dietary intake and physical activity in many people.[40 41] Thus, the COVID-19 pandemic could also have influenced our results.

Conclusion

In this population of runners, the occurrence of LLT was common. One-third had ever experienced an LLT, while 6% had present symptoms. AT was the most prevalent type of LLT, and prevalence rates for all types of LLT were higher in men than in women. Age and running load were positively associated with LLT. An association between nutritional factors in the habitual diet and LLT was not observed, which might be explained by the relatively high diet quality in this cohort of runners compared with the general population.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants the Medical Ethical Review Commission from Wageningen University & Research assessed the study protocol and concluded that it did not fall within the scope of the Medical Research Involving Human Subjects Act (WMO), and formal medical ethical approval was not required. This study was, however, conducted following the ethical principles contained in the current revision of the Declaration of Helsinki. Participants gave informed consent to participate in the study before taking part.

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Supplementary Table 1 Components and Dutch dietary guidelines of the DHD15-index and their threshold (minimum score) and cut-off (maximum score)

	Components	Component type	Dutch dietary guidelines 2015	Minimum score (=0)	Maximum score (=10)
1.	Vegetables	A	Eat at least 200 grams of vegetables daily.	0g/day	≥200 g/day
2.	Fruit	A	Eat at least 200 grams of fruit daily.	0 g/day	≥200 g/day
3.	Wholegrain products*	A	a. Eat at least 90 grams of wholegrain products daily.	0 g/day	≥90 g/day
		R	b. Replace refined grain products with wholegrain products.	No consumption of wholegrain products OR ratio wholegrain/refined grains ≤ 0.7	No consumption of refined grain products OR ratio wholegrain/refined grains ≥ 11
4.	Legumes	A	Eat legumes weekly.	0 g/day	≥10 g/day
5.	Nuts	A	Eat at least 15 grams of unsalted nuts daily.	0 g/day	≥ 15 g/day
6.	Dairy†	O	Eat a few portions of dairy products daily, including milk or yoghurt.	0 g/day OR ≥750 g/day	300-450 g/day
7.	Fish‡	A	Eat one serving of fish weekly, preferably oily fish.	0 g/day	≥15 g/day
8.	Tea	A	Drink three cups of black or green tea daily.	0 g/day	≥450 g/day
9.	Fats and oils	R	Replace butter, hard margarines, and cooking fats with soft margarines, liquid cooking fats, and vegetable oils.	No consumption of soft margarines, liquid cooking fats, and vegetable oils OR ratio liquid cooking fats/solid cooking fats ≤ 0.6	No consumption of butter, hard margarines, and cooking fats OR ratio liquid cooking fats/solid cooking fats ≥ 13
10.	Coffee	Q	Replace unfiltered coffee with filtered coffee.	Any consumption of unfiltered coffee	Consumption of only filtered coffee OR no coffee consumption
11.	Red meat	M	Limit consumption of red meat.	≥100 g/day	≤45 g/day
12.	Processed meat	M	Limit consumption of processed meat.	≥50 g/day	0 g/day
13.	Sweetened beverages and fruit juices	M	Limit consumption of sweetened beverages and fruit juices.	≥250 g/day	0 g/day
14.	Alcohol	M	If alcohol is consumed, intake should be limited to one Dutch unit (10 grams of ethanol) daily.	Women: ≥ 20 g ethanol/day Men: ≥30 g ethanol/day	Women: ≤10 g ethanol/day Men: ≤10 g ethanol/day
15.	Salt	M	Limit consumption of table salt to 6 grams daily.	≥ 3.8 g sodium/day	≤ 1.9 g sodium/day
16.	Unhealthy choices	M	Limit consumption of unhealthy choices	> 7 choices/week	≤ 3 choices/week

Abbreviations: A, adequacy component; M, moderation component; O, optimum component; Q, qualitative component; R, ratio component.
Adequacy components are derived from a guideline that recommends increasing intake. Moderation components are derived from a guideline that recommends limiting intake. Dairy is an optimum component based on an optimal range of intakes, whereas coffee is a qualitative component based on the type of coffee. Ratio components are based on the ratio of intake of healthy and unhealthy products in that food group.
* This component consists of two subcomponents (a and b). Each subcomponent has a maximum score of 5 points.
† maximum of 40g cheese can be included.
‡ maximum of 4g lean fish can be included.

Supplementary Table 2 Personal characteristics and running characteristics in the total study population, and for men and women separately

	Total (n=1993)[†]	Men (n=891)	Women (n=1095)	p-value men vs women*	Missing (n)
Age, years	44 (34 – 54)	48 (37 – 57)	43 (32 – 52)	**<0.001**	
BMI, kg/m^2	22.3 (20.8 – 23.9)	22.8 (21.5 – 24.4)	21.6 (20.2 – 23.4)	**<0.001**	10
Running level				**<0.001**	
beginner	53 (3)	16 (2)	37 (3)		
intermediate, not competitive	1513 (76)	618 (69)	890 (81)		
competitive (in age group)	414 (21)	250 (28)	162 (15)		
(semi)professional	13 (1)	7 (1)	6 (1)		
Running years				**<0.001**	3
< 1 year	41 (2)	12 (1)	29 (3)		
1-2 years	155 (8)	62 (7)	93 (9)		
3-5 years	394 (20)	153 (17)	239 (22)		
6-9 years	418 (21)	180 (20)	238 (22)		
≥ 10 years	982 (49)	481 (54)	496 (45)		
Running, times/week	3.0 (2.0 – 4.0)	3.0 (2.5 – 4.0)	3.0 (2.0 – 3.0)	**<0.001**	1
Running, km/week	30 (20 – 42)	35 (25 – 50)	25 (17 – 40)	**<0.001**	5
Longest distance per week (km)	15 (10 – 20)	16 (12 – 21)	12 (10 – 17)	**<0.001**	166
Intensity most intensive training				**<0.001**	
moderately intensive	492 (25)	197 (22)	293 (27)		
intensive	1019 (51)	442 (50)	575 (53)		
very intensive	482 (24)	252 (28)	227 (21)		
Running in competitions (yes)	1623 (81)	734 (82)	884 (81)	0.330	1
Km on current shoes	450 (200 – 700)	500 (250 – 700)	400 (200 – 650)	**0.016**	513
Main surface				0.092	
running track	23 (1)	8 (1)	15 (1)		
hard surface	1154 (58)	535 (60)	615 (56)		
soft surface	176 (9)	63 (7)	111 (10)		
treadmill	5 (0)	3 (0)	2 (0)		
various	635 (32)	282 (32)	352 (32)		
Warming up (yes)	1266 (64)	569 (64)	693 (63)	0.954	2
Other sports besides running in past year (yes)	1203 (60)	459 (52)	738 (67)	**<0.001**	2
Other sports besides running (hours per week)	3.0 (2.0 – 5.0)	3.0 (2.0 – 5.0)	3.0 (2.0 – 5.0)	**0.003**	806

Data are presented as median (25th-75th percentile) for continuous variables, and n (%) for categorical variables.
* P-values were obtained with a Mann-Whitney U test for continuous variables and a Pearson Chi-square test for categorical variables; statistical significance (p<0.05) is indicated in bold.
[†] The total population includes 5 gender-neutral runners and 2 runners who did not fill in their gender.

Supplementary Table 3 Daily energy and nutrient intake in the total study population, and for men and women separately

	Total (n=1993)[†]	**Men (n=891)**	**Women (n=1095)**	**p-value men vs women***
Energy (kcal)	2095 (1700 – 2538)	2365 (1954 -2806)	1898 (1574 – 2270)	**<0.001**
Total carbohydrates				
(g)	229 (184 – 280)	259 (209 – 314)	209 (169 – 251)	**<0.001**
(En%)	44 (41 – 47)	44 (41 – 47)	44 (41 – 48)	0.199
Mono- and disaccharides (g)	98 (78 – 122)	103 (79 – 128)	95 (75 – 116)	**<0.001**
Polysaccharides (g)	129 (99 – 164)	154 (123 – 188)	113 (87 – 142)	**<0.001**
Total fat				
(g)	83 (64 – 103)	94 (73 – 115)	75 (59 – 93)	**<0.001**
(En%)	36 (32 – 39)	36 (32 – 39)	36 (32 – 39)	0.787
Saturated fatty acids (g)	27 (20 – 36)	31 (23 – 39)	25 (19 – 32)	**<0.001**
Monounsaturated fatty acids (g)	30 (24 – 38)	33 (26 – 42)	28 (22 – 35)	**<0.001**
Polyunsaturated fatty acids (g)	17 (13 – 22)	20 (15 – 25)	15 (11 – 20)	**<0.001**
Alpha-linoleic acid (ALA) (g)	1.73 (1.35 – 2.28)	1.95 (1.50 – 2.51)	1.60 (1.24 – 2.04)	**<0.001**
Eicosapentaenoic acid (EPA) (g)	0.08 (0.04 – 0.13)	0.08 (0.04 – 0.13)	0.08 (0.03 – 0.14)	0.111
Docosahexaenoic acid (DHA) (g)	0.11 (0.04 – 0.17)	0.10 (0.04 – 0.17)	0.11 (0.03 – 0.18)	0.437
Cholesterol (mg)	198 (141 – 270)	217 (156 – 296)	183 (130 – 246)	**<0.001**
Total protein				
(g)	76 (63 – 93)	87 (72 – 102)	70 (57 – 84)	**<0.001**
(En%)	15 (13 – 16)	15 (13 – 16)	15 (13 – 16)	0.485
Vegetable protein (g)	39 (30 – 49)	44 (35 – 55)	35 (27 – 43)	**<0.001**
Animal protein (g)	38 (27 – 48)	41 (31 – 53)	35 (25 – 45)	**<0.001**
Alcohol (g)	4 (1 – 10)	6 (2 – 13)	3 (1 – 8)	**<0.001**
Fibre (g)	26 (21 – 33)	29 (23 – 36)	24 (19 – 30)	**<0.001**
Retinol (µg)	377 (243 – 575)	469 (298 – 692)	325 (213 – 468)	**<0.001**
Retinol equivalents (µg)	813 (592 – 1089)	846 (610 – 1141)	791 (583 – 1047)	**<0.001**
Vitamin B1 (mg)	1.0 (0.8 – 1.2)	1.1 (0.9 – 1.3)	0.9 (0.7 – 1.0)	**<0.001**
Vitamin B2 (mg)	1.4 (1.1 – 1.8)	1.6 (1.3 – 2.0)	1.3 (1.1 – 1.6)	**<0.001**
Vitamin B6 (mg)	1.6 (1.3 – 2.0)	1.8 (1.4 – 2.2)	1.5 (1.2 – 1.8)	**<0.001**
Folate (present in food by nature) (µg)	266 (216 – 325)	276 (222 – 340)	260 (211 – 316)	**<0.001**
Folate equivalents (µg)	288 (230 – 358)	300 (238 – 380)	278 (224 – 342)	**<0.001**
Vitamin B12 (µg)	3.9 (2.7 – 5.4)	4.2 (3.1 – 5.8)	3.6 (2.5 – 4.9)	**<0.001**
Vitamin C (mg)	92 (69 – 120)	88 (64 – 118)	94 (73 – 121)	**<0.001**
Vitamin D (µg)	2.7 (1.9 – 3.9)	3.2 (2.2 – 4.4)	2.4 (1.7 – 3.4)	**<0.001**
Vitamin E (mg)	14 (11 – 18)	15 (12 – 19)	13 (10 – 16)	**<0.001**
Calcium (mg)	988 (769 – 1251)	1052 (804 – 1310)	938 (732 – 1183)	**<0.001**
Total iron (mg)	12 (10 – 14)	13 (11 – 16)	11 (9 – 13)	**<0.001**
Haem iron (mg)	0.7 (0.3 – 1.1)	0.8 (0.5 – 1.2)	0.6 (0.3 -1.0)	**<0.001**
Non haem iron (mg)	11.2 (9.1 – 13.6)	12 (10 – 15)	11 (9 – 13)	**<0.001**
Magnesium (mg)	388 (314 – 475)	431 (350 – 519)	360 (292 – 435)	**<0.001**
Zinc (mg)	10 (8 – 12)	11 (10 – 14)	9 (8 – 11)	**<0.001**
Selenium (µg)	43 (35 – 53)	48 (39 – 57)	40 (32 – 48)	**<0.001**

Data are presented as median (25^{th}-75^{th} percentile).
* P-values were obtained with a Mann-Whitney U test; statistical significance ($p<0.05$) is indicated in bold.
[†] The total population includes 5 gender-neutral runners and 2 runners who did not fill in their gender.

Supplementary Table 4 DHD2015-index score and its component scores in the total study population, and for men and women separately

	Total (n=1993)†	**Men (n=891)**	**Women (n=1095)**	**p-value men vs women***
DHD2015-index total score†	93.1 (81.3 – 103.8)	88.7 (77.1 – 100.2)	96.3 (85.0 – 106.3)	**<0.001**
DHD2015-index component scores				
1. Vegetables	8.2 (5.0 – 10.0)	6.8 (4.0 – 10.0)	9.4 (5.9 – 10.0)	**<0.001**
2. Fruit	10.0 (5.7 – 10.0)	10.0 (5.0 – 10.0)	10.0 (6.4 – 10.0)	**<0.001**
3a. Wholegrain products intake	5.0 (3.0 – 5.0)	5.0 (5.0 – 5.0)	4.6 (2.3 – 5.0)	**<0.001**
3b. Ratio wholegrain/refined grains	5.0 (3.1 – 5.0)	5.0 (2.8 – 5.0)	5.0 (3.3 – 5.0)	0.317
3. Wholegrain products total‡	9.5 (6.5 – 10.0)	10.0 (7.1 – 10.0)	8.7 (6.2 – 10.0)	**<0.001**
4. Legumes	10.0 (5.5 – 10.0)	10.0 (5.5 – 10.0)	10.0 (5.5 – 10.0)	0.222
5. Nuts	8.2 (2.6 – 10.0)	8.3 (2.9 – 10.0)	8.2 (2.6 – 10.0)	0.634
6. Dairy	6.3 (2.9 – 9.3)	6.6 (3.2 – 9.6)	6.0 (2.8 – 9.0)	0.069
7. Fish	6.4 (2.7 – 9.9)	6.3 (2.8 – 9.9)	6.5 (2.7 – 10.0)	0.875
8. Tea	4.3 (0.3 – 9.7)	2.2 (0.0 – 7.6)	6.5 (1.6 – 10.0)	**<0.001**
9. Fats and oils	10.0 (1.7 – 10.0)	10.0 (1.8 – 10.0)	10.0 (1.4 – 10.0)	0.569
11. Red meat	10.0 (8.0 – 10.0)	10.0 (7.1 – 10.0)	10.0 (8.6 – 10.0)	**<0.001**
12. Processed meat	6.6 (2.8 – 9.2)	5.1 (0.9 – 8.2)	7.5 (4.4 – 9.7)	**<0.001**
13. Sweetened beverages and fruit juices	8.7 (5.3 – 9.7)	7.7 (3.5 – 9.4)	9.0 (6.9 – 9.9)	**<0.001**
14. Alcohol†	10.0 (10.0 – 10.0)	10.0 (8.7 – 10.0)	10.0 (10.0 – 10.0)	**<0.001**
16. Unhealthy choices	0.0 (0.0 – 0.0)	0.0 (0.0 – 0.0)	0.0 (0.0 – 0.0)	**<0.001**

Data are presented as median (25th-75th percentile).
Component 10 (coffee) and 15 (salt) could not be calculated from FFQ data.
* P-values were obtained with a Mann-Whitney U test; statistical significance ($p<0.05$) is indicated in bold.
† The total population includes 5 gender-neutral runners and 2 runners who did not fill in their gender. The guidelines for alcohol intake are different for men and women. Therefore the component score for alcohol and the total score could not be calculated for gender-neutral runners and runners with unknown gender. Thus, these scores for the total population are calculated for 1986 runners.
‡ Sum score of components 3a and 3b.