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RESEARCH NOTE

Exposure to nickel from the metal equipment in the gym [version 1; peer review: awaiting peer review]

Denis Vinnikov [1], Zhangir Tulekov[1], Anar Dushpanova[1], Zhanna Romanova[1], Aleksandr Sokolov[1], Valeriya Sokolova[1], Tair Nurpeisov[2]

[1]al-Farabi Kazakh National University, Almaty, 050040, Kazakhstan
[2]Scientific-Research Institute of Cardiology and Internal Diseases, Almaty, 050000, Kazakhstan

v1 **First published:** 17 Jan 2019, **8**:68 (https://doi.org/10.12688/f1000research.17791.1)
Latest published: 17 Jan 2019, **8**:68 (https://doi.org/10.12688/f1000research.17791.1)

Abstract
It remains unclear whether gym customers are exposed to any nickel from the metal equipment and if the exposure is associated with the duration of contact. Therefore, the aim of this study was to ascertain exposure to nickel measured through nickel concentration in the hair in those exercising in a fitness gym. We enrolled 100 amateur athletes in one of the gyms in Almaty, Kazakhstan (all men, median age 30 (interquartile range (IQR) 10) years), exercising from 2 to 7 days a week for 40 to 180 minutes and their age- and sex-matched controls who did not exercise. All subjects filled in the questionnaires on the exercising patterns, smoking and occupational exposure and then donated 0.25 g of head hair, in which nickel was measured using atomic absorption spectrophotometry. Hair nickel concentration ranged from 0 to 8.5 µg/g with notable left-skewness towards low concentrations in both groups. Hair nickel concentration was not associated with age, smoking or occupation, but was significantly lower in amateur athletes compared to controls (median 0 (IQR 0.5) vs. 0.9 (IQR 1.4) µg/g). More days a week in a gym, longer workout history, longer workout duration or supplements use did not increase the probability of being stratified in a high-exposure subgroup (defined as 75th percentile of hair nickel concentration and higher); however, there were more smokers in a low-exposure group ($p<0.05$). With the mixed pattern of exposure, gym goers may be unlikely exposed to more nickel from the metal equipment in the gym, however the exposure may depend on the specific alloy composition.

Keywords
gym, nickel, spectrophotometry, exposure

Open Peer Review

Reviewer Status *AWAITING PEER REVIEW*

Any reports and responses or comments on the article can be found at the end of the article.

Corresponding author: Denis Vinnikov (denisvinnikov@mail.ru)

Author roles: Vinnikov D: Conceptualization, Formal Analysis, Investigation, Supervision, Writing – Original Draft Preparation; **Tulekov Z**: Data Curation, Methodology, Writing – Review & Editing; **Dushpanova A**: Data Curation, Formal Analysis, Methodology, Validation, Writing – Review & Editing; **Romanova Z**: Data Curation, Formal Analysis, Project Administration, Resources, Writing – Review & Editing; **Sokolov A**: Methodology, Resources, Supervision, Validation, Visualization, Writing – Review & Editing; **Sokolova V**: Investigation, Methodology, Resources, Supervision, Visualization, Writing – Review & Editing; **Nurpeisov T**: Data Curation, Formal Analysis, Project Administration, Validation, Writing – Review & Editing

Competing interests: No competing interests were disclosed.

Grant information: The author(s) declared that no grants were involved in supporting this work.

How to cite this article: Vinnikov D, Tulekov Z, Dushpanova A *et al.* **Exposure to nickel from the metal equipment in the gym [version 1; peer review: awaiting peer review]** F1000Research 2019, **8**:68 (https://doi.org/10.12688/f1000research.17791.1)

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Introduction

Exercising in a gym has become quite a prevalent leisure activity in adults, given significant benefit of regular exercising on cardiovascular health, mood and probably self-confidence. Little is known, however, about the adverse effects of attending the gym with the corresponding exposures. Gym goers may be exposed to a variety of chemicals inside gyms including metal bars and barbells. Those are usually produced of stainless steel, and the chemical composition of the latter may vary; however, selected metals in the steel, such as nickel, may be associated with adverse health effects in environmental and occupational studies. Thus, nickel is a known carcinogen[1,2] and may also cause allergic dermatitis.

Very few studies, however, assess exposure of those exercising in the gyms to nickel. There is only one report with a small sample to show higher concentrations of nickel from the contact with bars compared to non-exercising individuals[3]. In this presentation, they found nickel both on the bars and the skin of exercising individuals using acid test. A case of allergic dermatitis was also reported in a regularly exercising individual[4], but no studies with larger samples have approached the issue of nickel exposure and its adverse health effects in the gyms. Whether nickel found in the palm skin of gym customers may lead to higher nickel blood concentrations, therefore causing systemic effects, remains unknown. In professional sportsmen, nickel blood concentrations were found to be higher compared to controls[5], and given that nutritional intake of nickel in these two groups did not differ, such findings should raise some concern as to whether such elevated concentration is associated with exposure in the gyms and has any negative impact on health.

With all that scarce evidence, it remains unclear whether gym customers are exposed to any nickel from the metal equipment and if the exposure is associated with the duration of contact. Therefore, the aim of this study was to ascertain exposure to nickel measured through nickel concentration in the hair in those exercising in a fitness gym compared to non-exercising controls.

Methods

Ethical approval

This study was approved by the Committee on Bioethics of al-Farabi Kazakh National University. All subjects in this study provided written informed consent to participate and donate head hair sample for nickel analysis.

Recruitment and variables measured

We enrolled 100 customers from two gyms in of one the popular chains in Almaty, Kazakhstan. Anyone willing to participate and regularly exercising in a gym could be included in the study. The only exclusion criterion was female sex, as there were very few women in the gym. Subjects were invited to participate by authors DV, ZhT or AD in a random fashion, thus, reducing selection bias. Data were collected in July and August 2018. Sample size calculation with a given statistical power did not seem feasible for this study, as we could not find any other similar analysis of this kind in the literature; therefore, we set the sample size of 100 subjects. We also enrolled sex- and age-matched controls who were their friends or acquaintances to ensure comparable lifestyle, eating habits and general interests to control for confounding. Controls should not have exercised in a gym for at least 2 years prior to the enrollment in the study. All subjects were asked to fill in a questionnaire[6], which consisted of the demographic part, followed by detailed section in the exercising pattern, smoking, occupational exposure and the use of supplements. We asked the respondents how many days they normally attended the gym, what the duration of the usual workout was in minutes, how long was the gym exposure history, whether gloves were used in the gym, whether a contact allergy to metals in the gym was ever experienced, and whether any fitness tracker or supplement was used.

We then detailed smoking history with a series of questions and stratified all subjects into never, former or daily smokers and ascertained the number of smoked cigarettes a day along with the smoking durations in months or years. Occupational history section contained a series of questions whether a subject was a student at a time of the survey, had any employment in the office or had any occupational exposure with metal.

Hair nickel concentration measurement

We measured hair nickel concentrations in all subjects and treated the concentration as a marker of exposure to nickel. Hair (at least 0.25 g) was cut in from the occipital. Hair samples were then washed using non-ionized surface-active solution, then acetone and then with non-ionized water. Weighed samples were treated with nitric acid (67%) and hydrogen peroxide (30%). Nickel concentrations in the samples were tested using atomic absorption spectrophotometry on Perkin Elmer AAnalyst 400 with HGA 900 (USA) and following officially approved protocol[7]. The lower limit of detection (LOD) in our analysis was 0.05 μg/g.

Statistical analysis

Hair nickel concentrations were the primary outcomes in this analysis and compared in the main and control groups using non-parametric Mann-Whitney U-test, since all concentrations were left-skewed. Demographic attributes, smoking and occupational exposure were tested as predictors in bivariate models and compared between the groups. We used NCSS 12 (Utah, USA) for all computations. $P<0.05$ was considered significant.

Results

Hair nickel concentration

Hair nickel concentration ranged from 0 to 8.5 μg/g, with notable left-skewness towards low concentrations. Thus, 25th percentile was 0 μg/g; 50th, 0.38 μg/g; and 75th, 1.22 μg/g. A total of 56 (28%) subjects showed concentrations below the limit of detection (LOD); 52% of amateur athletes and 4% of those in the control group had nickel levels below LOD ($p<0.05$). Hair nickel concentration was not associated with age, smoking or occupation, but was significantly lower in amateur athletes than controls (Table 1). Raw information of hair nickel concentration, in addition to all questionnaire answers, are available on OSF[6].

Variables in gym-goers

In the main group, the gym attendance frequency ranged from 2 to 7 days a week; however, most subjects did so 3 times a week (67%). Workout duration ranged from 40 to 180 minutes; median, 90 (IQR 37.5) minutes. The overall gym exposure was from 1 month to 30 years, with the median 2 (IQR 4.4.) years. Only 17% of those in the gym used gloves for weightlifting on a regular basis, and 4% ever had dermatitis that they associated with the gym equipment use. A total of 16% use fitness tracker in the gym on a regular basis, and 56% use any sort of supplements to attain more visible results in the gym; there was no statistically significant correlation between these two variables.

Analysis of hair nickel concentration

When stratified by the 75th percentile of nickel hair concentration (0.505 µg/g) into low- and high-exposure gym customers only, we found no difference in age, the number of workouts days a week, workout duration, overall exposure to gym equipment in years or supplement use (Table 2). Surprisingly, there were significantly more subjects wearing gloves, believed to protect the skin from contact with metal, in the high-exposure group. Similarly, the latter group had fewer smokers compared to those with lower nickel concentrations.

Discussion

To our knowledge, this is the first report on hair nickel concentrations in those attending the gym compared to controls, in which we could not confirm higher exposure to nickel in amateur athletes. Guided by the pilot presentations that exposure to metal equipment in the gym may result in greater nickel absorption, we compared hair nickel concentrations in regular exercisers compared to those abstaining from the gym, but found higher hair nickel concentrations in the latter group. We conclude that it was not dermal contact with metal equipment in the gym, but fewer smokers or specific nutritional habits in the gym goers group that could explain their lower hair nickel concentrations.

Table 1. Demographic profile and nickel concentrations in the amateur athletes and controls.

Variables	Total	Gym	No gym
N (%)	200 (100)	100 (50)	100 (50)
Age, years	29 (8.8)	30 (10)	29 (9)
Never smokers, N (%)	84 (42)	33 (33)	51 (51)*
Daily smokers, N (%)	59 (30)	23 (23)	36 (36)*
Students, N (%)	49 (25)	17 (17)	32 (32)
Office staff, N (%)	89 (45)	48 (48)	41 (41)
Occupational exposure to metal, N (%)	5 (3)	4 (4)	1 (1)
Ni in hair, µg/g	0.38 (1.22)	0 (0.5)	0.9 (1.4)*

*P<0.05, gym-goers compared to control.

Table 2. Selected predictors of higher hair nickel concentrations in gym-goers.

Variables	High exposure	Low exposure
N (%)	25 (25)	75 (75)
Age, years	31 (12)	30 (8)
Days a week in a gym	3 (0.5)	3 (1)
Workout duration, min	90 (45)	100 (30)
Overall workout history, years	2 (4.4)	2 (4.4)
Use of gloves, N (%)	12 (48)	5 (7)*
Supplements use, N (%)	16 (64)	40 (53)
Daily smoking, N (%)	6 (24)	53 (71)*
Occupational exposure to metals, N (%)	1 (4)	3 (4)

*P<0.05, high-exposure compared to low-exposure group.

The sources of nickel in the population may range from absorption to food, smoking, place of residence, lifestyle habits, such as exposure, to diverse occupational exposures. Despite some likelihood of exposure to nickel in those exercising in the gym, we could not find similar reports in the literature and could not compare the concentrations we found with other settings. However, there are plenty of other environmental and occupational publications with reported hair nickel concentrations.

The most surprising finding of this analysis was nickel concentration in controls. Although we deliberately matched controls with exercisers to ensure similar eating patterns, their hair nickel concentrations were quite high and even exceeded the concentrations in occupationally exposed industrial workers[8]. In order to allow for comparison between those exercising in the gym and controls, nutritional nickel consumption should be equal in both groups. Direct assessment of the amount of consumed nickel does not seem feasible in a regular setting; therefore, computational methods are often used in studies of athletes[5]. However, such methods yield more approximation than accuracy and therefore will lead to a notable exposure classification bias. Hence, in our study, we preferred to enroll controls from friends, matched for age and sex, to allow for comparable nickel consumption in the main group with controls.

The limitations of this analysis originate from its cross-sectional design. The overall sample size of 200 subjects may also limit statistical power. Another limitation is the use of matching rather than a detailed questionnaire on eating habits and computational method to ascertain food nickel consumption. Finally, we could not obtain detailed information on the metal composition of the steel used for a particular brand of metal equipment in the chain of gym under study. Guided by anecdotal reports in non-professional literature, stainless steel for metal equipment in the gym is very likely produced of steel with some nickel content, but we could not confirm whether the given equipment had any nickel in it, either from the original documentation or, alternatively, using acid nickel testing.

To conclude, this pilot study of nickel exposure measured through hair nickel concentration in those contacting metal equipment in the gym failed to demonstrate greater hair nickel concentration in the latter compared to their non-exercising friends.

Data availability

Underlying data

Raw data for this study, including basic demographic information, answers to the questionnaire and hair nickel levels, are available on OSF. DOI: https://doi.org/10.17605/OSF.IO/RQJ3Z[6].

Extended data

The questionnaire in the original (Russian) and in English are available on OSF. DOI: https://doi.org/10.17605/OSF.IO/RQJ3Z[6].

Grant information

The author(s) declared that no grants were involved in supporting this work.

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