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Oral health and performance impacts in elite and professional athletes

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Keywords

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Abstract

Objectives: To measure dental caries, erosive tooth wear (ETW), periodontal health, self-reported oral health problems and performance impacts in a representative sample of UK elite athletes from different sports using standardised conditions, clearly defined clinical indices and a measure of impact on performance with evidence of validity in in sport.

Methods: Cross-sectional study, with a single, calibrated examiner, conducted in the local facilities of elite and professional UK athletes (UCL ethics number 6388/001). Main oral measures: dental caries (ICDAS), erosive tooth wear (BEWE), periodontal health (BPE) and athlete-reported performance impacts.

Results: We recruited 352 athletes from eleven sports. The mean age was 25 years (range 18-39) and 67.0% were male. We found caries (ICDAS code $\geq$3) in 49.1% of athletes, ETW (BEWE score of $\geq$7) in 41.4%, gingival bleeding on probing/presence of calculus (BPE score1 or 2) in 77.0% and pocket probing depths of at least 4mm (BPE score 3 or 4) in a further 21.6%. One in five athletes reported previous wisdom teeth problems. The odds of having caries were 2.4 times greater in team sport than endurance sport (95% CI 1.3 to 3.2). The odds of having erosion were 2.0 times greater in team sport than endurance sport (95% CI 1.3 to 3.1). Overall 32.0% athletes reported an oral-health-related impact on sport performance: oral pain (29.9%), difficulty participating in normal training and competition (9.0%), performance affected (5.8%) and reduction in training volume (3.8%). Other impacts were difficulty with eating (34.6%), relaxing (15.1%) and smiling (17.2%). Several oral health problems were associated with performance impacts.

Conclusions: This is the first large representative sample study of oral health in athletes from different sports at elite level. Although experience of oral disease differs by sport, the prevalence, in UK elite and professional athletes, is substantial, with common self-reported performance impacts. Regular screening and use of effective oral health promotion strategies may minimise performance impacts from poor oral health

Introduction and background

To compete at the highest level, athletes need to be well prepared, fit and healthy and oral health is integral to general health and wellbeing.[1] Protection of athletes' health through prevention of injury and illness is an important consideration in high performance sport.[2] High quality data on the prevalence and impact of health related incidents is important to establish the burden of health problems and inform appropriate preventive and health promotion strategies[3]. In addition to clinical measures, the use of self-reported measures of health, wellbeing and performance can contribute to a greater understanding of issues pertaining to athlete development and welfare [4-6].

Previous research suggests that poor oral health and associated self-reported negative impacts are common[7-9], however limitations with previous studies included convenience sampling, [8] the use of multiple examiners without reported calibration [8,9] and an outcome measure of impact on performance without evidence of validity in sport. We hypothesised that athletes with dental disease would also report an impact on general health, along with negative psychosocial impacts such as difficulties with eating, sleeping and socialization, and sport performance impacts including pain and difficulties with participation in training and competition. This study aimed to evaluate the extent, severity and impact of oral health problems in a representative sample of elite athletes from different sports using a single trained examiner, standardised examination conditions and an outcome measure of impact on performance with evidence of validity in sport.

Methods

Medical directors of elite (Olympic and professional) sports groups (cycling, swimming, rowing, sailing, gymnastics, rugby, football, field hockey, athletics, rugby sevens) were offered the opportunity for their athletes to engage in the research by attending for a screening examination and provision of an oral health report. We aimed to recruit a minimum of 75% of each squad to the study. Athletes were directed to seek care from their usual dentist, however we arranged for treatment to be provided for athletes who were unable to access dental care. Eligible athletes were: a member of elite (Olympic or professional) training/development squad, aged 18 years or over, able to understand the consent process and able to understand and complete the

questionnaire, with the aid of a translator if required. For all sports except athletics, screening appointments were arranged for the complete squad on their behalf by a designated liaison person. For athletics, an appointment was arranged only if the athlete indicated s/he would like to accept the offer of screening. Following consent and screening, participating athletes completed a questionnaire. Ethics approval was received from University College London research ethics committee (Project ID 6388/001). Informed written consent was obtained. Participation in the study was entirely voluntary and with no obligation.

Oral health screening was undertaken by JG, an experienced clinical dentist and educator. We used the PUFA (Pulp, Ulcer, Fistula, Abscess) index[10] to measure oral sepsis; pericoronitis was assessed as the presence or absence of inflammation around a partially erupted third molar and the Basic Periodontal Examination (BPE) was used to measure periodontal health[11]. To measure ETW, we used the Basic Erosive Wear Examination (BEWE,[12] total BEWE score of $\geq$ 7 to represent ETW greater than normal physiological wear). Dental caries was measured using the International Caries Detection and Assessment system (ICDAS)[13]. Following a detailed review of the clinical indices, excellent examiner agreement with a gold standard was confirmed for measurement of established caries (kappa=0.9) and periodontal disease (kappa 0.8) and examiner repeatability for measurement of caries (kappa=1.0) and ETW (kappa=1.0). We also recorded any current complaints or pain related to teeth, sensitivity to hot or cold, bleeding when cleaning teeth, history of swelling or infection associated with any wisdom tooth or sport-related dental trauma in the previous year.

Athletes were examined supine under illumination from a mobile examination lamp (DARAY X100LED). Compressed air from a portable dental unit was used to dry the teeth (PDU II Standard, QDent), with a new set of sterile single use instruments (mddi code 52BT-1) for each athlete. A clinical record form (CRF) was designed, piloted and used to record clinical information at the screening appointment. Data were coded and entered into a spreadsheet by an independent person prior to their importing into the statistical package for analysis.

The research advisory group reviewed the questionnaire, which was piloted before use. Domains included: self-assessed general health status, oral health status, demographic characteristics,

psychosocial impacts, and the impact on performance in sport. In order to limit the length of the questionnaire we used three items, most likely to be relevant to this young, fit population, to assess impact on quality of life (difficulty eating/drinking, relaxing including sleeping and smiling, laughing or showing teeth without embarrassment) taken from the Oral Impacts on Daily Performance (OIDP) outcome measure used in the Adult Dental Health Survey for England, Wales and Northern Ireland (ADHS 2009)[14,15]. We employed the Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire[16] to assess impact on performance, given that a systematic review[17] identified this measure as having greatest validity in sport

We used IBM SPSS Statistics for Windows (Version 22.0. Armonk, NY). Counts and percentages summarised the categorical data and Chi square tests (or Fisher's exact tests as appropriate) were used to compare percentages in different groups, with post-hoc comparisons where necessary, and calculation of odds ratios as appropriate. A significance level of 5% was selected for all hypothesis tests. This report was guided by the STROBE statement of observational studies[18].

Results

All sports contacted agreed to participate and we recruited 352 athletes (256 athletes on podium potential/placement programmes for the 2016 Rio Olympic Games and 96 professional athletes) into the study with questionnaire data available for up to 344 (97.7%, 95% CI 95.5 to 98.9). The main reason for non-attendance at the screening appointment was training or competing elsewhere. Eight questionnaires were not returned due to time constraints. We achieved our target of at least 75% completeness in all sports except athletics (26.3%, 95% CI 17.8 to 36.9). Overall, we screened 79.4% (95% CI 75.4 to 83.0) of eligible athletes (Figure 1).

Figure 1 Sports, numbers of athletes recruited to the study and percentage completeness of each sample group

The median age of the participants was 25 years (range 18 to 39) and 67.0% were male (Online Table 1). Two hundred and seventy five (80.4%, 95% CI 75.4 to 83.9) athletes recorded ethnicity as white British and 162 (47.4%, 95% CI 41.9 to 52.4) said they had or were studying for a University degree. There were 50 (14.2%, 95% CI 10.9 to 18.3) athletes in the strength and power category (athletics, gymnastics, sprint cycling and sprint swimming), 143 (40.6%, 95% CI 35.6 to

45.8) in the endurance category (swimming, cycling, rowing,) and 159 (45.2%, 95% CI 40.0 to 50.4) in the mixed category (football, rugby, hockey, sailing). The demographic make-up of the endurance and mixed sports categories was similar but those in the strength and power category were younger and composed more females and athletes from ethnic groups other than white British.

Figure 2 Percentage contribution of each sport and sport category to the total sample

The median number of sound and unrestored teeth per athlete was 27 (range 12 to 32), and 173 (49.1%; 95% CI 44.0 to 56.6) had an established carious lesion (ICDAS code $\geq$3) in at least one tooth (Online Tables 2 and 3). Of those with caries (DT $\geq$ 1), the median number of teeth affected was 2 (range 1 to 13). For those with one or more restorations (71.6%; 95% CI 66.7 to 76.1) the median number of teeth affected was 4 (range 1 to 19). Caries was not associated with age, gender, ethnicity or education, however the percentage with DT $\geq$ 1 was highest in rugby (61.1%; 95% CI 49.5 to 71.5) and football (61.5%; 95% CI 42.5 to 7.6) and lowest in rowing (33.3%; 22.7 to 46.0). The percentage with DT $\geq$ 1 in the mixed sport category (56%; (95% CI 48.2 to 63.5) was higher than that in endurance (38.5%; 95% CI 31.0 to 46.4) with an odds ratio of 2.03 (95% CI 1.3 to 3.2).

Overall 41.4% (95% CI 37.0 to 47.3) of athletes had ETW with a difference between the genders (Online Table 4); 48.7% of men and 28.4% of women had a BEWE score of $\geq$ 7 (P<0.001). In terms of severity 41 (11.7%; 95% CI 8.7 to 15.5) athletes scored between 9 and 13. ETW was most prevalent in football (73.1%; 95% CI 53.7 to 86.5) and least prevalent in sailing (26.7%; 95% CI 10.5 to 52.4) and rowing (26.7%; 95% CI 17.0 to 39.1). ETW differed between mixed (51.6%; 95% CI 43.9 to 59.2) and endurance (35%; 95% CI 27.6 to 43.1) sports categories (OR 2.0; 95% CI 1.3 to 3.1, P=0.015).

We found excellent periodontal health (BPE code 0 as worst score) in 4 (1.1%; 95% CI 0.3 to 3.0) athletes. Gingival bleeding on probing/calculus or other plaque retentive factors present (BPE codes 1 or 2) as the worst finding was present in 77.3% (95% CI 72.6 to 81.3) of athletes and a pocket probing depth of $\geq$ 4mm (BPE code 3 or 4) in a further 21.6% (95% CI 17.6 to 26.2). In

terms of extent, 87.5% (95% CI 83.3 to 90.3) of athletes had a BPE score of at least1 in three or more sextants (Online Tables 5 and 6).

We recorded infections around wisdom teeth at the time of clinical examination for 4 (1.1%; 95% CI 0.3 to 3.0) of athletes and 12 (3.4%; 95% CI 1.9 to 5.9) had at least one PUFA finding. The proportions of athletes reporting oral health problems were: 7.7% (95% CI 5.3 to 11.0) current pain or problem related to teeth, 26.7% (95% CI 22.3 to 31.6) sensitivity to hot or cold, 23.3% (95% CI 19.1 to 28.0) swelling/infection around wisdom teeth in previous 12 months, 12.8% (95% CI 9.7 to 16.7 sport-related dental trauma in previous 12 months and 39.0% (95% CI 34.0 to 44.1) bleeding when cleaning teeth at least occasionally.

Nine of ten athletes (90.1%; 95% CI 86.5 to 92.9) assessed their general health as very good or good and seven of ten (69.2%; 95% CI 64.1 to 73.8) assessed their oral health at this level (Online Tables 7 and 8). Overall 169 (49.1%; 95% CI 43.9 to 54.4) athletes reported a non-zero score for one or more psychosocial impacts within the previous 12 months (Online Tables 9 and 9a): difficulty eating or drinking; 119 (34.6%; 95% CI 29.8 to 39.8), difficulty relaxing (including sleeping); 52 (15.1%; 95% CI 11.7 to 19.3), difficulty smiling, laughing or showing teeth without embarrassment; 59 (17.2%; 95% CI 13.5 to 21.5). The odds of an oral impact on daily performance was 2.7 (95% CI 1.2 to 6.0) times greater in cycling than rowing (P=0.013). Overall 110 (32.0%; 95% CI 27.3 to 37.1) athletes reported a non-zero score for one or more sport performance impacts within the previous 12 months (Online Tables 10 and 10a): difficulty in participating in normal training and competition; 9% (95% CI 6.4 to 12.5), reduced training volume; 3.8% (95% CI 2.2 to 6.4), performance affected; 5.8% (95% CI 3.7 to 7.9) and experienced oral pain; 29.9% (95% CI 25.3 to 25.0). The odds of an oral impact on sport performance was reduced by 41.0% in men compared to women (OR=0.6; 95% CI 0.4 to 1.0; P=0.030). A severity score out of 100 can be calculated for these problems and 31% of athletes reported a non-zero score; the highest score reported was 94.

Each variable was dichotomised to effect/no effect (Online Tables 11 and 12). Presence of dental caries was associated with non-zero score for difficulty eating (P=0.048). The presence of any PUFA lesion was also associated with non-zero scores for difficulty eating (P=0.027), relaxing

(P<0.001) difficulty participating in normal training or competition (P=0.002), experience of oral pain (P=0.001) and "any sport performance impact" (P=0.005). There were associations with oral health status and psychosocial impacts including pain (Table 1). For general health status there were associations between relaxing (including sleeping) and all sport performance impacts. Several self-reported oral health problems (Table 2) had an association with athlete-reported impacts on wellbeing or sport performance (Online Tables 13 and 14): current pain or problem related to teeth (P<0.001), sensitivity to hot or cold (P=0.006), bleeding when cleaning teeth (P=0.04) and history of swelling or infection around wisdom teeth (P=0.001).

Discussion

This study provides strong evidence of the prevalence of oral health diseases and associated performance impacts in elite athletes; established caries was present in 49.1% of athletes and ETW present in 42.0%. Excellent periodontal health was rare; more than three quarters (77.0%) of athletes had gingival bleeding on probing/calculus present and we measured a pocket probing depth of 4mm or more in a further 21.0%. We judged the samples to be representative of each team (other than athletics) with each at least 75% participation in the study. The odds of having caries in mixed/team sport were 2.4 (95% CI 1.5-3.8) times greater than in endurance athletes (38.5%) and odds of erosion 2.0 (95% CI 1.3 to 3.1) times greater in team/mixed sport than endurance sport. Caries prevalence was not associated with age, gender, ethnicity or educational status however ETW was more prevalent in male athletes.

The most commonly reported impacts were oral pain (29.9%) and difficulties with eating (34.6%). Other impacts were: difficulty relaxing (15.1%), smiling (17.2%) and participation in normal training and competition (9.0%). Furthermore, 5.8% felt their performance was affected and 3.8% reported a reduction in training volume

This study has several strengths. This is the most methodologically robust study to evaluate oral health and associated self-reported performance impacts in elite athletes across different sports and is one of the largest studies of oral health in sport with 352 athletes recruited. We achieved a 75-100% sample in each team/sport with track and field the only exception at 26%. All examinations were conducted by a single experienced dentist using clearly defined clinical and

valid self-reported outcome measures; the inclusion of different sports allows comparison of oral health status for the first time. It is reasonable therefore to generalise the findings to elite and professional sport in the UK. We noted a difference in prevalence of oral disease between sports and further analysis of self-reported oral health and risk behaviours may provide an insight into the reasons for this difference. The risk of systematic bias was mitigated by training and calibration of the examiner against a gold standard. However repeat examination of a sample of athletes during the screening visits to assess ongoing repeatability was not possible due to athlete time constraints. No radiographs were taken in this study and therefore the estimates of oral disease may under-report actual prevalence.

These data are consistent with data from previous research[7-9] (Online Figure 1). We did not recruit a control population to the study but a cautious comparison with a similar age group from the most recent national oral health survey in England and Wales (ADHS 2009) can be made[15]. We reported established caries in 49% of athletes compared to 36% of adults aged 25-34 from the ADHS 2009; 15% of athletes had 3 or more teeth affected compared to 10% of a comparable group from the ADHS 2009. We found that 22% of athletes had pocket probing depths of $\geq$ 4mm compared to 19% of adults aged 16-24 from the ADHS 2009. We reported ETW in 42% of athletes with a BEWE score 9 or more in 12%; the ADHS 2009 reported toothwear in 52% of adults aged 16-24 with moderate wear in 4%; the prevalence of ETW was greater in men than women in both groups. Performance impacts (non-zero) reported in the ADHS 2009: impact on eating (20%), impact on relaxing (12%), impact on smiling (15%) and impact on work (4%) are generally lower than those reported by the athletes in this survey who may have higher expectations of physical function, psychological function and perceived health[19]. It is important to recognise that the ADHS 2009 includes greater representation of disadvantaged populations who are known to have higher levels of oral disease. Therefore the sporting environment may negatively influence oral health in elite athletes within this sample. Furthermore the lifetime burden of treatment need and effect on quality of life on athletes should be considered[20]. Severe events such as acute dental or oro-facial infections can lead to time lost from training and even competition, however they occur infrequently. Chronic impacts which may not lead to time loss, but rather a reduction

in quality of training, are commonly reported, and at elite level may have important consequences[21].

The prevention of oral disease is largely dependent upon people changing behaviour in line with professional guidance[22]. Therefore interventions which are based upon behaviour change theory[23] and include all stakeholders to improve quality and relevance may have a better chance of success[24,25]. Further research is needed to identify appropriate evidence-based strategies to embed oral health promotion within sport.

CONCLUSIONS

Oral diseases and associated negative performance impacts are common in UK elite and professional athletes. Regular screening and the use of effective oral health promotion strategies may minimise performance impacts from poor oral health.

Conflict of interest

This project was jointly funded by a grant from GSK and UCL IMPACT (award number 157871). The authors declare no conflict of interest. The Centre for Oral Health and Performance is part of the UK IOC Research Centre for Prevention of Injury and Protection of Athlete Health with the Institute of Sport Exercise and Health (ISEH) and the National Centre for Sport and Exercise Medicine (NCSEM).

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Table 1 Table 1 Associations between clinical indicators of oral health, general and oral health status, and athlete-reported performance impacts (non-zero score)

	Number (%) with the condition and at least one impact on daily activity	Odds ratio	(95% CI)	P value	Number (%) with the condition and at least one impact on sport performance	Odds ratio	(95% CI)	P value
All (n = 344)	169 (49.1%)				110 (32%)			
Number of decayed teeth								
None	78/175 (44.1%)	1			55/177 (31.1%)	1		
One or more	91/169 (54.5%)	1.52	(0.99-2.33)	0.050	55 (32.9%)	1.089	(0.692-1.714)	0.711
Any PUFA								
No	160/332(48.2%)	1			101/332 (30.4%)	1		
Yes	9/12 (75.0%)	3.23	(0.86-12.12)	0.080	9/12 (75%)	6.861	(1.819-25.876)	0.005
Periodontal condition								
BPE 0, 1 or 2	80/268 (29.9%)	1			80/268 (29.9%)	1		
BPE 3 or 4	30/76 (39.5%)	1.53	(0.90-2.60)	0.110	30/76 (39.5%)	1.533	(0.903-2.602)	0.114
Erosion								
BEWE score < 6	68/198 (34.4%)	1			65/198 (32.8%)	1		
BEWE score ≥ 7	51/146 (34.9%)	0.97	(0.62-1.53)	0.910	45/146 (38.8%)	0.912	(0.576-1.444)	0.693
Self-reported general health								
Very/good	145/310 (46.8%)	1			93/310 (30.0%)	1		
Fair- very poor	24/34 (70.6%)	2.731	(1.264-5.903)	0.011	17/34 (50%)	2.333	(1.142-4.769)	0.020
Self-reported oral health								
Very/good	97/238 (40.8%)	1			68/238 (28.6%)	1		
Fair-very poor	72/106 (67.9%)	3.078	(1.899-4.989)	<0.001	42/106 (39.6%)	1.641	(1.015-2.652)	0.043

Table 2 Associations between self-reported oral health problems and athlete-reported performance impacts (non-zero score)

	Number (%) with the condition and at least one impact on daily activity	Odds ratio	(95% CI)	P value	Number (%) with the condition and at least one impact on sport performance	Odds ratio	(95% CI)	P value
Current pain/problem								
No	146/317 (46.1%)	1			89/317 (28.1%)	1		
Yes	23/27 (85.2%)	6.735	(2.277–19.921)	<0.001	21/27 (77.8%)	8.966	(3.503-22.949)	<0.001
Sensitivity to hot or cold								
No	113/253 (44.7%)	1			72/253 (28.5%)	1		
Yes or occasionally	56/91 (61.5%)	1.982	(1.215-3.235)	0.006	38/91 (41.8%)	1.802	(1.095-2.966)	0.021
Bleeding when cleaning teeth								
No	74/176 (42%)	1			48/176 (27.3%)	1		
Yes or occasionally	61/112 (54.5%)	1.649	(1.023-2.657)	0.040	38/112 (33.9%)	1.369	(0.820-2.287)	0.230
History of wisdom tooth swelling/infection*								
No	106/262 (40.5%)	1			70/262 (26.7%)	1		
Yes	63/82 (76.8%)	6.735	(2.277-19.921)	0.001	40/82 (48.8%)	2.612	(1.565 - 4.360)	0.001

Figure 1 Sports, numbers of athletes recruited to the study and percentage completeness of each sample group

Figure 2 Percentage contribution of each sport and sport category to the total sample