Title

Refractive error and vision correction in a general sports playing population.

Running title

Refractive Correction in a sporting population

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Refractive error, vision correction, spectacles, contact lenses, refractive surgery, sports.

Purpose: To evaluate the prevalence of refractive error among people who exercise or play sport, and also the type of vision correction they use during sport. Furthermore, to assess attitudes towards different kinds of vision correction used in various types of sports in an amateur sports playing population.

Method: A questionnaire was used for people engaging in sport and data was collected from sport centres, gyms and Universities that focused on the motor sciences.

Results

One thousand, five hundred and seventy-three questionnaires were collected (mean age 26.5 ± 12.9 years; 63.5% males). Nearly all (93.8%) subjects stated that their vision had been checked at least once. Fifty-three subjects (3.4%) had undergone refractive surgery (RS). The remainder, who did not have RS (n=1519), 580 (38.2%) reported a defect of vision; 474 (31.2%) were myopic, 63 (4.1%) hyperopic and 241 (15.9%) astigmatic. Logistic Regression Analysis showed that the best predictors for myopia prevalence were gender ($p<0.001$) and location of sport practice ($p<0.001$). Sports that present higher prevalence of outdoor activity have lower prevalence of myopia. Contact Lens (CL) penetration over the study sample was 18.7%. CLs were the favourite system of correction among people interviewed compared to spectacles and RS ($p<0.001$).

Conclusions

This study showed that sport was not associated with different levels of myopia prevalence in the adult population. However, subjects engaging in outdoor sports had lower rates of myopia prevalence. Penetration of CLs use in sport was 4 times higher than the overall adult population. CLs were the preferred system of correction in sports compared to spectacles or RS, but this preference was affected by the type of sport practiced and by the age and level of sports activity for which the preference was required.

Introduction

Good performance in sports requires a variety of visual abilities.[1-2] Testing of good visual function of sports players has been the object of many research studies and leads to the development of a new ophthalmic sub-speciality, *sport vision*. This has developed in order to spread the best practice in visual assessment, refractive correction and training of athletes[3]. The refractive correction used during motor activities could represent a barrier towards sports practice. Notwithstanding this, only two studies have reported the prevalence of refractive error in sports players[4-5]. Among the participants at the Amateur Athletic Union Junior Olympic Games, a high prevalence of refractive errors was found: 24.4% of myopia, 10.9% of hyperopia and 63.7% of astigmatism. Conversely, among the players of the national football and cricket teams in Nepal only 8.0% were found with refractive errors.[5]

More information about type of optical correction used during sport is present in the literature. Usually individuals prefer to wear contact lenses (CLs) rather than spectacles during sports; one paper suggested 14.8% preferred CLs whilst only 5.7% preferred spectacles.[4] At the 1994 Winter Olympic Games only 3% of the athletes who wore spectacles in everyday life used them during sport, whereas 94% of those who wore CLs in everyday life continued to use them in sport.[6] Similar findings have been reported most recently,[7] i.e., 50.0% of spectacles-only wearers did not use them during sport compared to only 10.0% of CL wearers who did not use them for sport. Refractive surgery (RS) can be an alternative for people engaged in sport.[8,9]

This study aims to provide further evidence regarding the prevalence of refractive errors among sports players, to evaluate the type of optical correction and to assess attitudes towards visual correction.

The most common methods used to determine the prevalence of refractive errors in a population-based study are objective or subjective refraction[10,11] but self-reported classification of refractive errors by questionnaires has also been extensively used[12-16] allowing a decrease in terms of cost and time to collect data. Self-reported classification methods are considered particularly effective in demonstrating the presence of myopia.[17-19]

Methods

Participants and procedures

A survey was conducted at locations where a high density of people were engaging in sporting activities in Italy, such as gyms, sports centres and Universities that focused on the motor sciences. A questionnaire (Table 1) was administered to subjects practicing sports, who enrolled in the survey on a voluntary basis. Questionnaires were collected in the period from March 2014 to February 2015. The study was performed in agreement with local ethical protocols and the tenets of the Declaration of Helsinki were followed.

The questionnaire covered five main sections: (1) subject demographics, (2) Information about sport practice, (3) vision defects, (4) vision correction and finally (5) attitudes towards vision correction in sport.

Data analyses

Analyses are presented descriptively and statistically. Non-parametric statistics were used to analyse the data. The Chi-squared (χ^2) test was used to evaluate differences between demographics and the prevalence of refractive errors.

Logistic Regression Analysis (LRA) was used to explore the relationship between the

different refractive errors (myopic, hyperopic and astigmatic) as categorical dependent variables and age, gender, dimension of town of residence, years of engaging in sports, level of sports competition, and location of sports (outdoor versus indoor) as independent variables. LRA were run with list-wise deletions of participants that included only those participants who scored on all the variables in the model. Phi square coefficient was use to evaluate correlation between prevalence of myopia and location of sport activity in 2x2 tables.

Mann Whitney test, Kruskal–Wallis test and Spearman correlation coefficient (rho) were used to evaluate whether the perception of the importance of vision correction in sport was affected by variables like gender, age, type of sport and presence of refractive errors. The perception of best corrective option among sport players in the sample was calculated by χ^2 test.

To quantify the differential attitude toward refractive error correction such as conservative (Spectacles and CLs) or RS methods a Correction Preference Index was derived for each sports category. The results from spectacles and CLs were averaged to get a single value to be assigned to these conservative methods of correcting refractive error. This index was calculated for each sports category as the ratio between percentage of preference for conservative relative to the RS methods (conservative/RS), separately for age (teens versus adults) and level of competition (competitive versus non-competitive). A conservative/RS index of 1 means that subjects expressed the same attitude (i.e. level of preference) for both methods, a value smaller than 1 imply greater preference for RS than spectacles and CLs, while scores greater than one imply the opposite preference, i.e., greater preference for conservative methods.

Results

A total of 1573 valid questionnaires were analysed (out of 2300 distributed; 75 were eliminated for missing data) suggesting a completion rate of 68.4%. In Figure 1 age distribution is reported as a function of gender. Participant demographics and information about sport activity are reported in Table 2 and Figure 2.

Prevalence of refractive errors in sport

With regards to the previous eye examination history of the study population 1475 interviewees (93.8%) indicated that they had an eye examination and 94 (6.0%) that they never had an eye exam, and 4 (0.3%) did not respond.

Fifty-three subjects (3.4%) had undergone RS: 23 subjects (43.4%) reported to be myopic before surgery, 1 Hyperopic (1.9%), 11 astigmatic and myopic (20.8%), 5 astigmatic and hyperopic (9.4%) and 13 (24.5%) did not answer.

Any subject who had previously undergone RS was excluded from the calculation to determine the prevalence of refractive errors. This resulted in a total sample size of 1519 patients who were analysed (table 3). Of this sample 38.2% had a refractive error (31.2%, 4.1% and 15.9% for myopia, hyperopia and astigmatism respectively – some patients reported they had astigmatism plus myopia or hyperopia).

In Table 3 the data regarding refractive errors as a function of gender and age is reported (5 age groups were created), with the percentages referring to the prevalence in the total population of 1519 subjects. The refractive error of the subjects were affected by both age (χ^2=13.3, p=0.01) and gender (χ^2=37.3, p<0.001). For the age group, the analysis of standardized residual demonstrated that is the group of youngest people (9-17 years) that resulted in statistical significance. Examining the overall sample, myopia and astigmatism prevalence was affected by

gender (χ^2=29.4, p<0.001 for myopia; χ^2=28.5, p<0.001 for astigmatism) while only myopia and hyperopia were significantly affected by age group (χ^2=11.9, p=0.018 and χ^2=15.8, p=0.003 respectively). For the latter, the group of oldest people (over 45) resulted in a significant analysis (standardized residual=3.0).

Examining females specifically, age group affected only myopia prevalence (χ^2=13.6, p=0.009). In males, age group affected myopia, hyperopia and astigmatism prevalence (χ^2=16.1, p=0.003; χ^2=10.1, p=0.039 and χ^2=11.9, p=0.018 respectively).

Three different logistic regression analyses (LRA) were carried out to explore the effect of variables such as age, gender, size of the town of living, level of sporting competition, location of sporting practice (outdoor versus indoor), days of training per week and years of practising sport on the prevalence of myopia, hyperopia and astigmatism respectively (Table 4). For the myopic condition LRA showed that the best predictors were gender (B=0.56, SE=0.12, Wald=21.3, p<0.001) and location of sporting practice (B=0.37, SE=0.13, Wald = 8.99, p <0.001). For the hyperopic condition LRA showed that the best predictor was age (B=0.04, SE=0.01, Wald=11.29, p<0.01) . Finally, for the astigmatic condition, LRA showed that the best predictors were gender (B=0.75, SE=0.15, Wald=24.17, p<0.001) and age (B=0.02, SE=0.13, Wald =8.67, p <0.01).

Correlations between all dependent variables were examined to ensure that inter-correlations between them would not bias the analyses. The degree of inter-correlation between the dependent variables was relatively low (range 0.03 to 0.4) which is a necessary pre-requisite for the application of the LRA.

Amongst the factors linked to sporting activity, an interesting finding was that the location of sport practice (indoor versus outdoor) appears to be linked to the prevalence of myopia. On the other hand, it appears that all the other factors linked

to sporting activity (level of sporting competition, days of training per week and years of practicing a sport) as well as the size of the town of living do not predict prevalence of refractive error.

Considering the importance of the location of sport practice for myopia, the relationship between these two factors was further explored in order to reveal the presence of systematic effects due to other variables. In Figure 3 myopia prevalence have been plotted as a function of the prevalence of outdoor activity for each sport. Although there is a statistically significant association (Phi correlation 0.12, $P < 0.001$), it is evident that the actual differences among sports is quite small with slightly less myopia prevalence in subjects practising outdoor sports activities apart from 3 types of sporting activities (*fighting sports*, *aquatic sports* and *other sports*).

The respondents were also asked if they had a problem regarding near vision due to their increasing age and whether they required a reading correction (presbyopia). One hundred twenty six participants, with an age range between 39.7 and 79.7 years (8% of the total sample), answered yes to this question.

Modality of optical correction in sports

The optical correction used by sports players was calculated, including their usage during the sport. The numbers used in this analysis were all subjects who had not undergone RS (n=580) plus those who have had RS but declared that they still had a refractive error (n=19); thus a total sample of 599 subjects.

Table 5 shows the results together with outcomes about use of additional protective glasses. The results indicate that the majority of sports players with refractive errors use an optical correction (98%). However, while people wearing CLs tend to use

them also for sport activity (92.5%), who wears spectacles tend to remove them during sport.

Figure 4 shows the percentage of sports players wearing the different kind of CLs used in everyday life and for sport. Results show that people tend to wear always the same type of CL in everyday life and in sport ($\chi^{2=}$6.1, p=0.29). The most popular CLs were daily disposable, followed by soft CLs that were replaced at intervals of between 1 week and 1 month. It seems that the preference among sports players for the different kind of CLs does not change between sport and everyday life activities.

Attitudes towards vision correction in sport

Attitudes towards vision correction in sport are reported in Table 6 for the overall sample (n=1573).

The importance that sports players attribute to visual correction in sport was not affected by gender (Mann-Whitney, p=0.23), or age (Spearman's rho =-0.02, p=0.34). The type of sport practiced by interviewees significantly affected the importance attributed to the visual correction in sport (Kruskal-Wallis, p<0.001). Specifically, individuals practicing competitive sport perceived that visual correction to be more important (Kruskal-Wallis, p<0.001). A significant positive correlation was found between years of sport practice and the importance attributed to the visual correction in sport (Spearman's rho=0.06, p=0.03) and also between 'days per week' of training and importance attributed to the visual correction in sport (Spearman's rho =0.06, p=0.03).

Having or not having a refractive error did not affect the importance that sports players attribute to vision correction in sport, (Kruskal-Wallis, p=0.12). However, if myopic individuals are compared to all other types of ametropia then the former

attributed a statistically significant greater importance to vision correction in sport (Mann Whitney, p=0.02).

Contact lenses were regarded as the best corrective option amongst the all the interviewees (with a percentage of prevalence of about 50% or higher) regardless of the scenario considered: adults or teenagers, or playing competitively or not (χ^2, p=<0.001 in all cases).

To reveal further differences within each sports group with regard to the subjective perception of the best corrective options, an averaged Correction Preference Index was calculated (Conservative/RS) (see Methods for more details). The Correction Preference Indexes shown in Figure 5 were those obtained in cases of adult playing sports activity separated for level of competition (competitive versus non-competitive). Figure 5 shows that in the majority of non-competitive sports people expressed a greater preference for the conservative methods (index bigger than 1), with the only exception of *rugby* and *others sports*. Note that *bat and ball sports*, *basket* and *balance and coordination sport* are the three sports with the greatest Index (17.9, 11.8, 10.8). This means that conservative methods are preferred more than ten times than RS in these three sports. In the competitive sports people expressed an overall lower preference for the conservative methods respect to the non-competitive sport, as indicated by the general lower index. This indicates that in competitive sports practiced by adults, people attribute greater importance to RS. Specifically, it was observed that for *rugby*, *fighting sports* and *racquet sports* people expressed a preference for the RS (i.e., index smaller than 1) while a preference for the conservative methods (i.e., index bigger than 1) still remains greater for all the others sport. Note that *rugby* is the sport with the lowest index (0.4) implying that RS is preferred more than two times than Lens and Spectacles in this sport. Overall,

these results indicate that in adults the attitude for the correction modality is extremely affected by the type of sport and the level of competition. In some sport activities like *rugby* and *fighting sport* people are very much in favor of the RS, but only if they practice these sports at competitive level.

The Correction Preference Indexes shown in Figure 6 were those obtained for the case of teenaged sporting activity separately for competitive and non-competitive players. Figure 6 shows that in all the competitive and non-competitive sports players expressed a greater preference for the conservative methods (i.e., index bigger than 1), with no exceptions. Note that, like in adults, *basket*, *balance and coordination sport* and *bat and ball sports* are the three for non-competitive sports with the greatest Index (70.4, 70.4 and 37.4). This means that conservative methods are preferred ninety times more than RS in these three sports. In teenagers scenario, the difference between the competitive and non-competitive sport is much less marked than in adults' scenario. This likely implies that people are aware of the invasiveness level of the RS and consider this method more appropriate for adult people, independently to the level of competition of the sports they practice.

Discussion

This study represents an attempt to have a look at the prevalence of refractive errors, behaviours and attitudes towards vision correction during sport practice on large scale through a wide survey on amateur Italian sport subjects.

Prevalence of refractive errors in sport

Before discussing the results of the present study in terms of refractive errors prevalence, it is important to focus briefly on the methodology used. Self-reported classification of refractive errors by questionnaires has been extensively used

especially to explore familiar refractive status[12-16] allowing a decrease in terms of cost and time to collect data. In spite of this a certain prudence should be always keep in commenting the data because, unless for myopia which can be detected effectively, in case of hyperopia and astigmatism self-reported classification method is considered less effective.[17-19] Moreover, sensitivity and specificity of correct self-identification can be affected by the method of questioning. In two studies performed with English language questionnaires, three different methods of questioning, that used optometric terminology (direct method), layman terminology and descriptive explanation (indirect method), have been carried out.[17,19] The best validity of the questionnaire was achieved if an indirect method[17] or a combination of optometric terminology descriptive explanation is used.[19] Even though data about the effectiveness of self-identification of refractive errors for Italian speakers are not available in literature, it is possible to speculate that, considering in Italian language layman terms to indicate refractive errors do not exist (there is no such phrase as short-sightedness) and the only terminology used are the optometric one (i.e. myopia), interviewees should not have a problem identifying their own refractive error.

In this study it was found that refractive errors were affected by several factors linked to the demographics of the sample such as age and gender. Specifically, gender seemed to be a strong predictor for myopia and astigmatism (shown to be greater in females than males) whilst age resulted significant in regression analysis only for astigmatism and hyperopia (more so in in older subjects).

The gender-based difference in myopia prevalence found in this study (Table 3 and 4), is greater than observed in other studies.[16, 20] For example Vitale et al[20] reported that myopia prevalence was higher in females (39.9%) than males (32.6%) among

the 20-39 years old subjects. Moreover, in many studies females did not have a higher prevalence of myopia but, on the contrary, a higher prevalence of hyperopia.[21-24] A possible explanation is the link to the interaction with location of the sport practice. In this study the ratio between outdoor/indoor sports for males and females was extremely different (see below in the discussion); males performed significantly more outdoor sports (551 out of 999; 55.2%) compared to females (146 out of 574; 25.4%). Considering that in subjects practicing indoor sports, myopia prevalence was greater (see Table 3) this could have biased the prevalence for two genders.

With respect to the relationship between age and refractive errors, this study found in the study sample hyperopia prevalence increased with age, as demonstrated both with bivariate analysis and regression model (Table 3 and 4), is in agreement with literature.[23] However it is more difficult to comment data about the relationship between age and myopia. For bivariate analysis myopia prevalence is more common amongst younger female interviewees and that is in agreement with current literature.[23] However, this finding has not been found in logistic regression, which is likely due to the opposite trend of myopia prevalence across age ranges in females and males.

The second main finding is that amongst refractive errors in the sport sample only myopia was different by some sport-related variables. The logistic regression (Table 4) showed that the location of sport activity - outdoor versus indoor- in the case of myopia this can help predict prevalence. Outdoor sport activity is associated with a lower prevalence of myopia. In addition, sports that present higher prevalence of outdoor activity have lower prevalence of myopia (Figure 2).

The lower prevalence of myopia in outdoor activities is a quite intriguing result because notwithstanding the role of genetic factors in the development of myopia are undoubtedly of importance, environmental factors may also play an important role.[11,25,26] Among environmental factors that can affect myopia progression it was reported that the degree of urbanisation[27] and the level of higher education[28] appear most important. Conversely, outdoor activity and sport have been suggested to have a protective action against myopia onset[29] and progression[29-33] even though the association between outdoor activity with less myopia progression has not been strongly established.[34] Present results may suggest that it is the time spent outdoors, rather than sport itself, that is the crucial protective factor against myopia as previously suggested.[35-36] A study by Read et at[37] further confirms this conclusion suggesting that exposure to bright outdoor light rather than greater physical activity is the real factor behind the association between myopia and less outdoor activity. However, it may be the case that outdoor sports may attract non-myopic individuals so further studies are needed to address this point.

Finally, a limitation of the study is that a number of potentially important factors regarding refractive error were not identified by the questionnaire such as age of onset of refractive error, the interviewee's occupation and parental history of refractive error. These variables may confound the relationship between the independent variables actually studied (interviewee's age, gender, sport variables) and the prevalence of refractive error.

Prevalence of Myopia in Sport: comparisons with previous studies in the general population

The prevalence of myopia in the sample studied was 31.2%, this percentage has been recalculated on the basis of the proportion of males/females in the 2014 European Standard Population to obtain an age-standardised myopia prevalence of 30.3%. This value is very close to that of the age-standardised prevalence of myopia in the general adult population estimated to be 30.6% in a recent epidemiological European meta-analysis.[10] The prevalence of myopia in sports players would seem to be very close to the prevalence of myopia in the European general population, however certain caution is necessary in generalizing this finding as the prevalence of myopia in the adult population of Western countries found in many studies varies from 17% to 49%.[26] whereas in Asia the prevalence of myopia can reach 80% of the population.[38] This wide variability is due to the fact that prevalence of refractive error is dependent on many factors including age, gender, race, environmental factors, and finally on the methods of assessment and classification.[26,39] In 2008 a survey carried out in Italy investigated the prevalence of refractive errors in the general population using a questionnaire.[40] Considering the similar methodology, locations and similar ethnicities an attempt to compare the results was made for each age group (Figure 7). It was found that there was no significant difference (χ^2; p was >0.05) in all cases). So sports practice does not appear to be related to a different levels of myopia prevalence in the adult population.

Modality of optical correction in sports

According to the literature[6,7] practicing sport in CLs is far easier than in Spectacles. This study showed that 92.5% of everyday life CLs wearers do continue to use CLs in sport compare to a rate of only 30.3% for spectacles wearers. This is likely due to the well-known advantages that CLs can provide in sport widely

reported.[3,41] These benefits could explain why penetration of CLs wearers in this study compare to general population was higher. This study found 18.7% CL penetration (294 CLs wearers out of 1573 interviewees) compared to the Italian adult population estimate of around 4.7%.[42] However the sample age distribution of this study was younger than the general Italian population and this can massage the figures for CL penetration to be higher, as it is known the average age of CL wearers is typically in the mid to late twenties.[9]

Attitudes towards vision correction in sport

The data showed that whilst age and gender do not affect the importance that sport players attribute to visual correction in sport, variables such as type of sport, level of sport practice, years of practice, and days of the week spent training do. Individuals practicing different types of sport have different perceptions of the importance of vision correction in sport s previously reported.[43] For example the importance reached level of 5.0±1.0 for a sport like *Volleyball* and dropped to 3.9±1.6 for *fitness*. This result could indicate a certain awareness among sport players that specific sports required higher visual skills than others.[3] Again, being myopic may result in giving greater importance to vision correction as most sports are performed in the open field where focusing at distance is especially important.

The latest aspect explored in terms of attitudes was the preference for the three main systems of optical correction (Table 6). Generally, CLs are the favoured system of correction as previously reported,[9] but this is affected by the type of sport practiced and the age and level of practice for which the preference is required. Interviewees demonstrated a capacity to understand the differences between the different options. For example if the preference is required for a scenario where teenagers have to practice sport then, the attitudes towards CLs and spectacles was stronger in

comparison to RS (which is in fact mostly prescribed after the third decade of life).[44] Maybe interviewees perceived CLs and Spectacles less invasive and safer options for young people.

If subject were required about their preference in case of competitive sport activity we observe a raise in CLs and RS (both more suitable for sport especially in competition)[3] compare to spectacles.

The Correction Preference Index (Figures 4 and 5) allows a clear picture of the attitude of sport players towards the conservative (Spectacles and CLs) and RS methods. Most RS techniques have a lower age limit so in most cases teenagers are not eligible to have RS, if the data for teenagers is excluded in this analysis an increase in popularity for RS can be seen. This can be demonstrated further in certain sports such as rugby and fighting sports, where there is a clear limitation of spectacle correction, and even CLs increasing the probability of injury and trauma.

Conclusions

Sport practice is not associated with different amounts of myopia prevalence, at least in the sample of age of the sample studied. Sports players have the same vision defects as the general population. The location of the sport practice (outdoor versus indoor) seems to affect myopia prevalence with outdoor activity being associated with lower rates of myopia prevalence. The presence of comparable vision defect prevalence in sport players make the accent on the modality of optical correction which in sports are particularly relevant. Practicing sport in CLs is by far easier than in Spectacles. Finally, people practicing different kind of sports have different perception of importance of vision correction in sport. Generally CLs are the favourite

system of correction, but this is affected by kind sport practiced and the age and level of practice for which the preference is required.

Disclosure

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1. General Information:

Gender: M/F Age:_____ Town of Living:_____

2. Sport practice information:

-Main sport practised:_____

-Location of sport activity: outdoor/indoor

-Years of practice of the main sport:_____

-Level of practice of the main sport: Competitive/Non Competitive

(competitive is defined as a sport activity finalised to achieve a performance in competition at whatever level)

-days of training per week of the main sport:_____

3. Information about vision defects:

-Ever had an eye examination sight test: Yes/No

-Undergone refractive surgery: Yes/No
if yes for which kind of defects:
Myopic (needing to use an optical correction mainly at distance),
Hyperopic (needing an optical correction mainly for close working distance, e.g. reading, PC etc.)
Astigmatic
Don't know

-Sight defect (refractive error): Yes/No
if yes for which kind of defects:
Myopic (needing to use an optical correction mainly at distance),
Hyperopic (needing an optical correction mainly for close working distance, e.g. reading, PC etc)
Astigmatic
Don't know

-Problem for near vision, arising with age, corrected to read (Presbyiopia): Yes/No

4. Information about vision correction

(only for those individuals having a visual defect, see section 3)

-Use an optical correction for the sight defect: No/Yes/ Yes but only for particular engagements (for example driving, watching television).

-In case of use of optical correction, of which type: Spectacles/Contact Lenses/Both.

-In case of use of Spectacles, Are they used in sport? Yes/No
if yes the same kind or a specific pair for sport purposes?

-In case of use of CLs, of which kind: RGP, OrthoK, daily disposable, soft CLs discharged and replaced normally in an interval between 1 week and 1 month, Soft Contact Lenses which are discharged and replaced over 1 month.

-In case of use of CLs Are they used in sport? Yes/No
if yes the same kind or a specific pair for sport purposes?

-Is it used a protective or sunglasses eyewear during sport practice? Yes/No

5. Attitudes towards vision correction in sport

-How much visual correction is important during the main sport practice.
Attitude was measured by a Likert scale that ranged from 1 (none) to 6 (very much).

-In case of the presence of a sight defect, which corrective option among Spectacles, Contact lenses or Refractive Surgery is the best for your main sport if considered:
-non competitive activity for adults (over 20 years)
-competitive activity for adults (over 20 years)
-non competitive activity for teenagers (under 20 years)
-competitive activity for teenagers (under 20 years)

Table 1: Summarised version of questionnaire used in the survey (please note the questionnaire was administered in Italian and above is a translation of the original questionnaire)

Age, mean ± SD (years)	26.5 ± 12.9 (range 9-79.7)
Gender, n (%)	574 (36.5%) females 999 (63.5%) males
Ethnicity	Minimal ethnic variation (about 95% Caucasian).
Site of collection, n (%)	1241 (78.9%) Sport Centres or Gyms 332 (21.1%) Motor science faculties
Size of town of living	887 (56.4%) small urban centres (less than 130000 people) 669 (42.5%) bigger urban centre (with more than 900000 people) 17 (1.7%) no response
Location of sport activity (N and %)	697 (44.3%) Outdoor 876 (55.7 %) Indoor
Years of practice of the main sport (mean ± SD)	9.9 ± 8.6
Level of practice of the main sport (N and %)	838 (53.3%) Competitive 709 (45.1%) Non-competitive 26 (1.7%) no response
Days of training per week of the main sport (mean ± SD)	3.2 ± 1.3

Table 2: Participant Demographics and sport information (n=1573).

	Total subjects (N)	ɔtal Refractive Errors (%)	Myopia; N (%)	Hyperopia; N (%)	Astigmatism; N (%)	Don't know/don't answer; N (%)
Female						
9-17	129	60 (46.5)	52 (40.3)	6 (4.7)	25 (19.4)	2 (1.6)
18-26	261	134 (51.3)	117 (44.8)	9 (3.4)	66 (25.3)	8 (3.1)
27-35	67	34 (50.7)	27 (40.3)	4 (6.0)	14 (20.9)	3 (4.5)
36-44	37	17 (45.9)	12 (32.4)	4 (10.8)	6 (16.2)	1 (2.7)
45+	57	21 (36.8)	11 (19.3)	6 (10.5)	13 (22.8)	3 (5.3)
Sub Total	**551**	**266 (48.1)**	**219 (39.7)**	**29 (5.3)**	**124 (22.3)**	**17(3.1)**
Age groups comparison (χ^2)		p=0.36	**p=0.009**	p=0.12	p=0.59	p=0.67
Males						
9-17	231	49 (21.2)	39 (16,9)	6 (2.6)	16 (6.9)	4 (1.7)
18-26	411	142 (34.5)	118 (28.7)	12 (2.9)	50 (12.2)	12 (2.9)
27-35	147	51 (34.7)	44 (29.9)	3 (2.0)	20 (13.6)	4 (2.7)
36-44	83	28 (33.7)	21 (25.3)	5 (6.0)	12 (14.5)	2 (2.4)
45+	96	44 (45.8)	33 (34.4)	8 (8.2)	19 (19.8)	3 (3.1)
Sub Total	**968**	**314 (32.4)**	**255 (26.3)**	**34 (3.5)**	**117 (12.1)**	**25 (2.6)**
Age groups comparison (χ^2)		**p<0.001**	**p=0.003**	**p=0.039**	**p=0.018**	p=0.91
Gender groups comparison all ages (χ^2)		**p<0.001**	**p<0.001**	p=0.10	**p<0.001**	p=0.57
All subjects						
9-17	360	109 (30.3)	91 (25.3)	12 (3.3)	41 (11.4)	6 (1.7)
18-26	672	276 (41.1)	235 (35.0)	21(3.1)	116 (17.3)	20 (3.0)
27-35	214	85 (39.7)	71 (33.2)	7 (3.3)	34 (15.9)	7 (3.3)
36-44	120	45 (37.5)	33 (27.5)	9 (7.5)	18 (15.0)	3 (2.5)
45+	153	65 (42.5)	44(28.8)	14 (9.2)	32 (20.9)	6 (3.9)
Total	**1519**	**580 (38.2)**	**474 (31.2)**	**63 (4.1)**	**241 (15.9)**	**42 (2.8)**
Age groups comparison (all subjects) (χ^2)		**p=0.01**	**p=0.018**	**P=0.003**	p=0.052	p=0.61

Table 3: Refractive error prevalence. Percentages are referred to overall population numbers, divided for gender and age, reported in first column. Total sample comprised 1519 subjects (subjects that have had RS were excluded).

Myopia			
Factors	***B (SE)***	***Wald***	***OR (CI)***
Gender	0.57 (0.12)	**21.31****	1.76 (1.39 – 2.24)
Age	0.01 (0.01)	1.22	1.01 (0.99 – 1.02)
Size of town of living	0.18 (0.12)	2.25	1.20 (0.95 – 1.50)
Level of sporting competition	-0.16 (0.14)	1.31	0.85 (0.65 – 1.12)
Location of sporting practice (outdoor, indoor)	0.37 (0.13)	**8.39***	1.44 (1.13 – 1.85)
Days of training per week	-0.04 (0.05)	0.69	0.96 (0.87 – 1.06)
Years of sport practice	-0.01 (0.01)	1.59	0.99 (0.97 – 1.01)
Hyperopia			
Factors	***B (SE)***	***Wald***	***OR (CI)***
Gender	0.52 (0.27)	3.66	1.68 (0.99 – 2.87)
Age	0.04 (0.01)	**11.29***	1.04 (1.02 – 1.06)
Size of the town of living	0.30 (0.26)	1.30	1.35 (0.81 – 2.27)
Level of sporting competition	0.00 (0.33)	0.00	1.00 (0.53 – 1.91)
Location of sporting practice (outdoor, indoor)	-0.16 (0.28)	0.30	0.86 (0.49 – 1.49)
Days of training per week	0.19 (0.10)	3.76	1.21 (1.00 – 1.47)
Years of sport practice	-0.03 (0.02)	3.02	0.97 (0.94 – 1.00)
Astigmatism			
Factors	***B (SE)***	***Wald***	***OR (CI)***
Gender	0.75 (0.15)	**24.17****	2.12 (1.57 – 2.86)
Age	0.02 (0.01)	**8.67***	1.02 (1.01 – 1.04)
Size of the town of living	0.07 (0.15)	0.22	1.07 (0.80 – 1.44)
Level of sporting competition	0.02 (0.18)	0.02	1.02 (0.72 – 1.46)
Location of sporting practice (outdoor, indoor)	0.09 (0.16)	0.32	1.09 (0.80 – 1.50)
Days of training per week	-0.10 (0.06)	2.66	1.10 (0.98 – 1.24)
Years of sport practice	-0.02 (0.01)	2.82	0.98 (0.96 – 1.00)

*Legend: * p <0.01; **<0.001*

Table 4: Factors affecting the statistics for the three logistic regressions runs for myopia, hyperopia and astigmatism as categorical dependent variable respectively.

Vision Correction Habits in sports people having a refractive error (n=599 subjects)	
Do you use an optical correction?	Always: 390 (65.1%): For particular activity: 197 (32.9%) Never: 10 (1.7%) No response: 2 (0.3%)
In case of use of optical correction, of which kind?	Only spectacles: 292 (48.7%) Only CLs: 32 (5.3%) Both spectacles and CLs; 262 (43.7%) No response: 13 (2.2 %)
For those using spectacle in everyday life (554 Ss), "**Do you use spectacles in sport activity?**"	Yes: 168 (30.3%); { Same pair: 129 (76.8%); Another type specific for sport: 36 (21.4%); No Response: 3 (1.8%) No: 378 (68.2%) No response: 9 (1.6%)
For those using CLs in everyday life (294 Ss), "**Do you use CLs in sport activity?**	Yes: 272 (92.5%) { Same pair: 249 (91.2%); Another type specific for sport: 20 (7.3%); No Response: 4 (1.5%) No: 21 (7.1%) No response: 1 (0.3%)

Use of protective glasses (all the sample, n=1573)	
Do you use any sunglasses or protective glasses during sport practice?	Yes 251 (16%): No: 1317 (83.7%) No response: 5 (0.3%)

Table 5: Optical correction of sport people and modality of use in sport.

Number of subjects)	Importance of Visual correction mean ± SD; (N)	Best corrective option for non-competitive activity for adults N (%)*			Best corrective option competitive activity for adults N (%)*			Best corrective option non-competitive activity for teenagers N (%)*			Best corrective option competitive activity for teenagers N (%)*		
		Specs	CLs	RS	Specs	CLs	RS	Specs	CLs	RS	Specs	CLs	RS
1573	4.6 ± 1.4	324 (22.0)	867 (58.8)	284 (19.3)	176 (12.6)	694 (49.5)	531 (37.9)	524 (37.8)	763 (55.0)	101 (7.3)	342 (24.8)	880 (63.9)	155 (11.3)

Table 6: Attitudes towards vision correction in sport. Importance of visual correction and preference for corrective option amongst spectacles, CLs and RS recorded by interviewees are reported. Importance of visual correction in sport was measured by a Likert scale that ranged from 1, none, to 6, very much.
*Please note that the total number of subjects does not add up to the total number of subjects in the study because some participants did not provided responses.

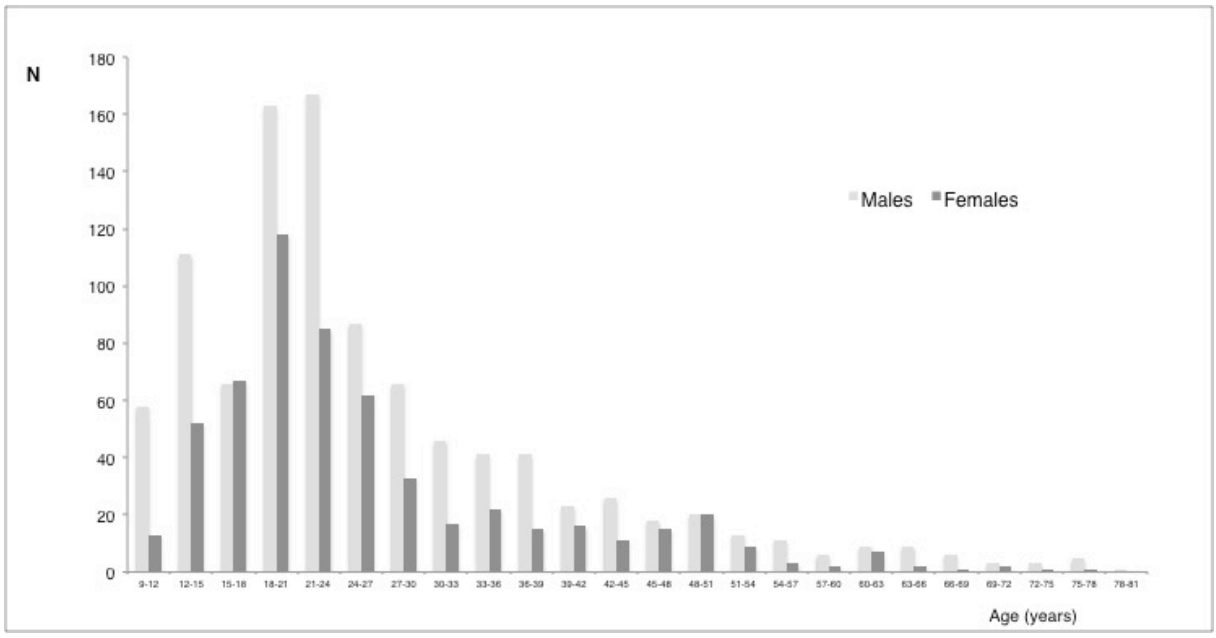

Figure 1: Age distribution of interviewees separated as a function of gender. The overall age distribution kurtosis and skewness resulted 1.9 and 1.4 respectively.

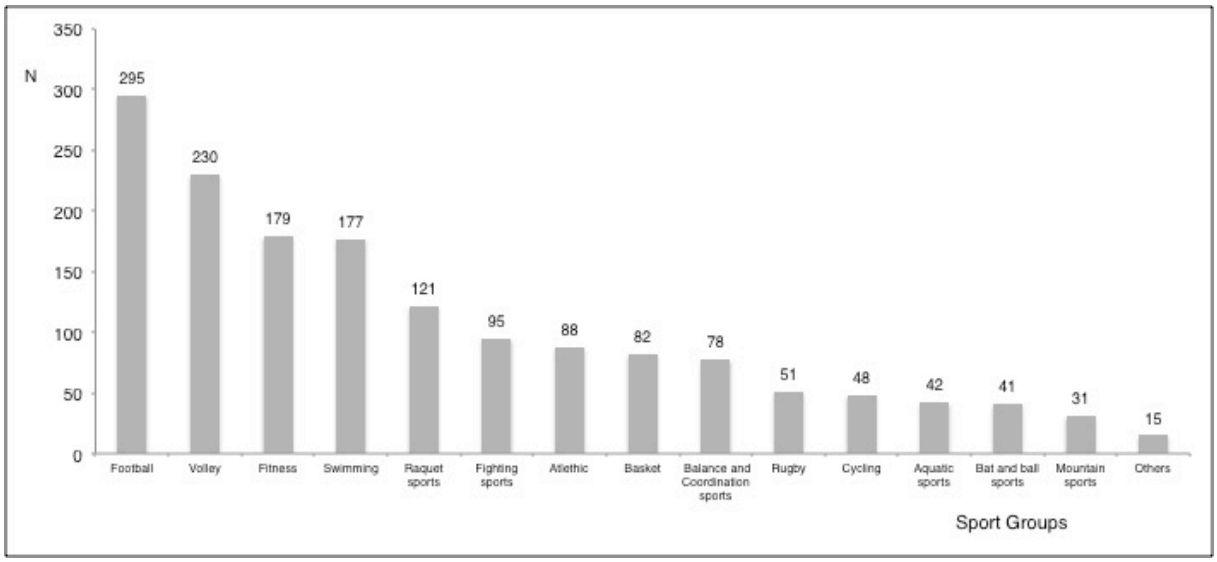

Figure 2: Distribution of the main sport practiced by interviewees. The main sports were clustered in 15 groups according to some features such as the visual and physical demands or the use of similar tools or if it is played in similar environments, e.g. balance and coordination sports (artistic gymnastics, rhythmic gymnastics, roller skating), bat and ball sports (hockey, softball, baseball); fighting sports (boxing, fencing, karate, kick boxing, kung-fu, judo, taekwondo); fitness (aerobics, aqua fitness, body building, fitness, low-impact exercise, spinning, pilates, yoga); aquatic sports (canoeing, free-diving, synchronized swimming, water polo, windsurfing).

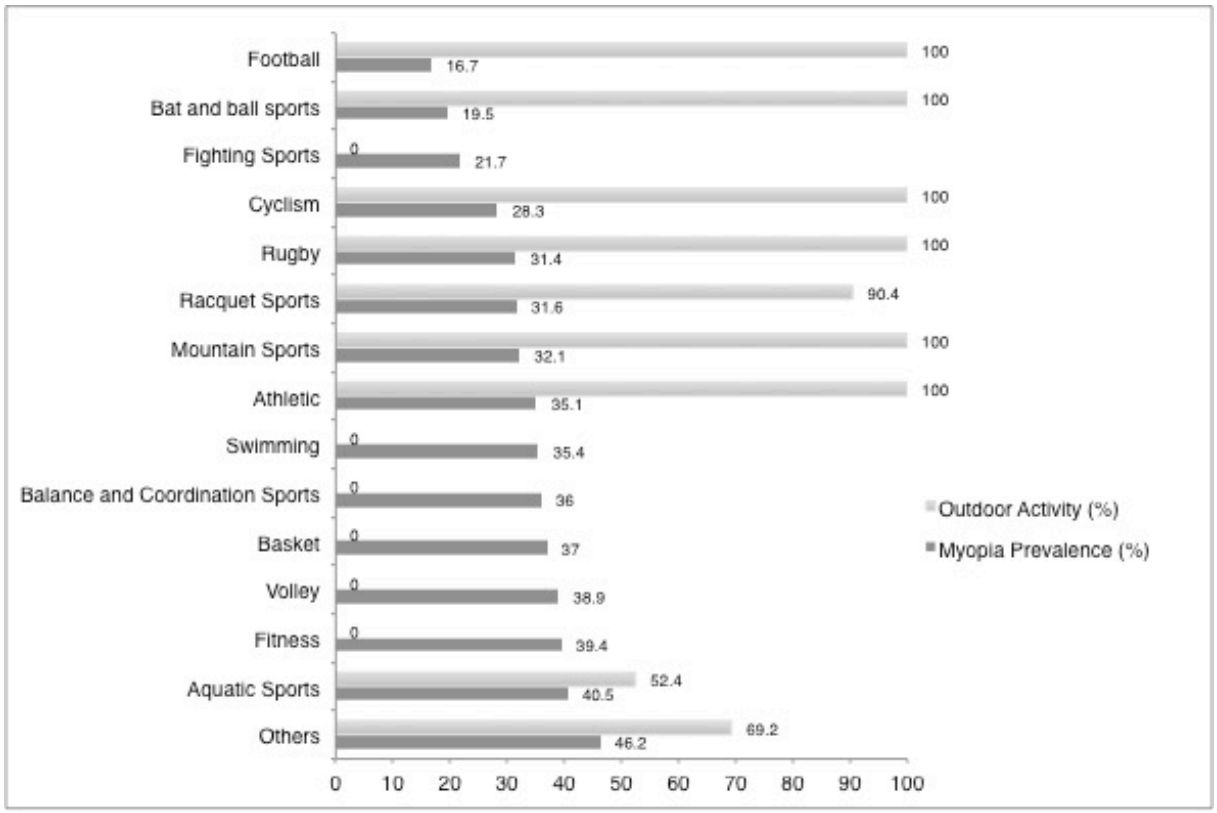

Figure 3: Myopia prevalence and outdoor activity prevalence (%) for each single sport group. The groups are displayed from top to bottom as a function of myopia prevalence.

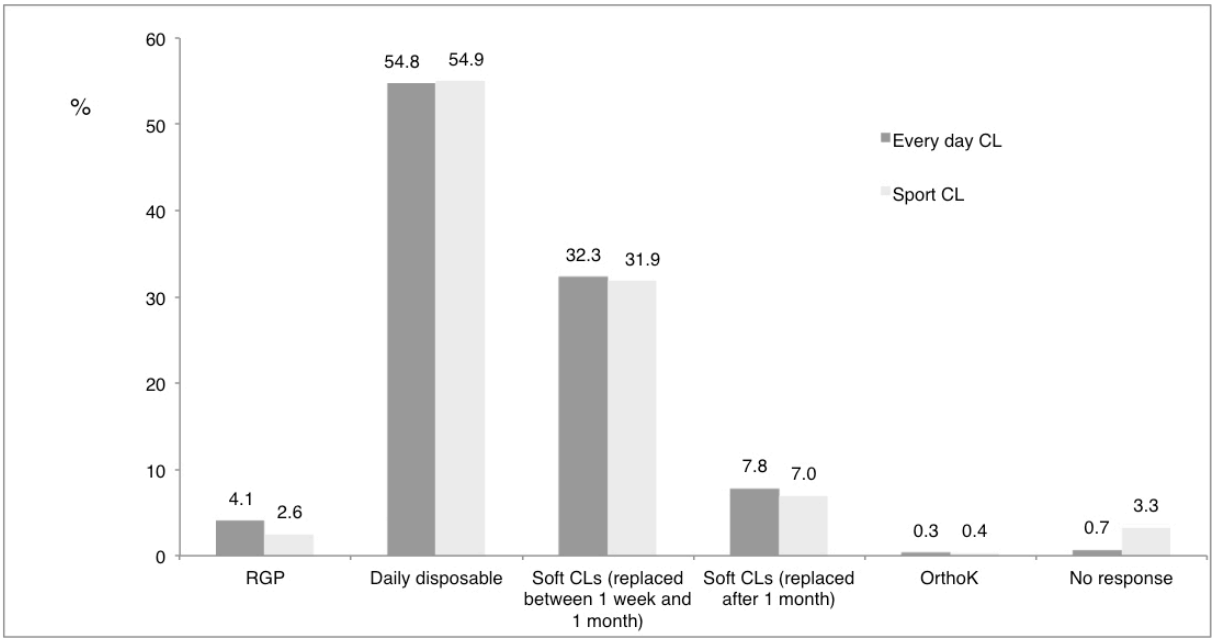

Figure 4: Percentage of different kind of CLs (%) used in everyday life and in sport.

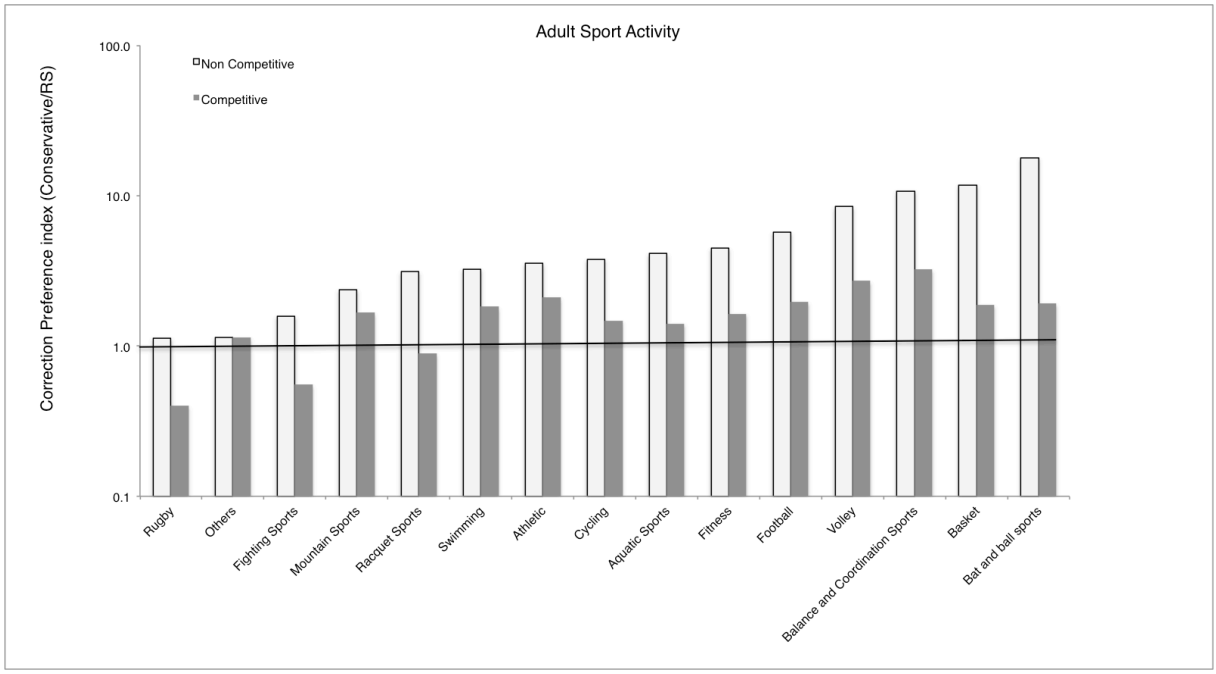

Figure 5: Correction Preference index (Conservative/RS) in different sports for the Adult sport practice scenario.

Index was calculated as the sum of spectacles and CLs preference divided RS preference. A Conservative/RS index of 1 (means that conservative and RS are equally preferred by the interviewees) is marked in the figure by a thicker black horizontal line).

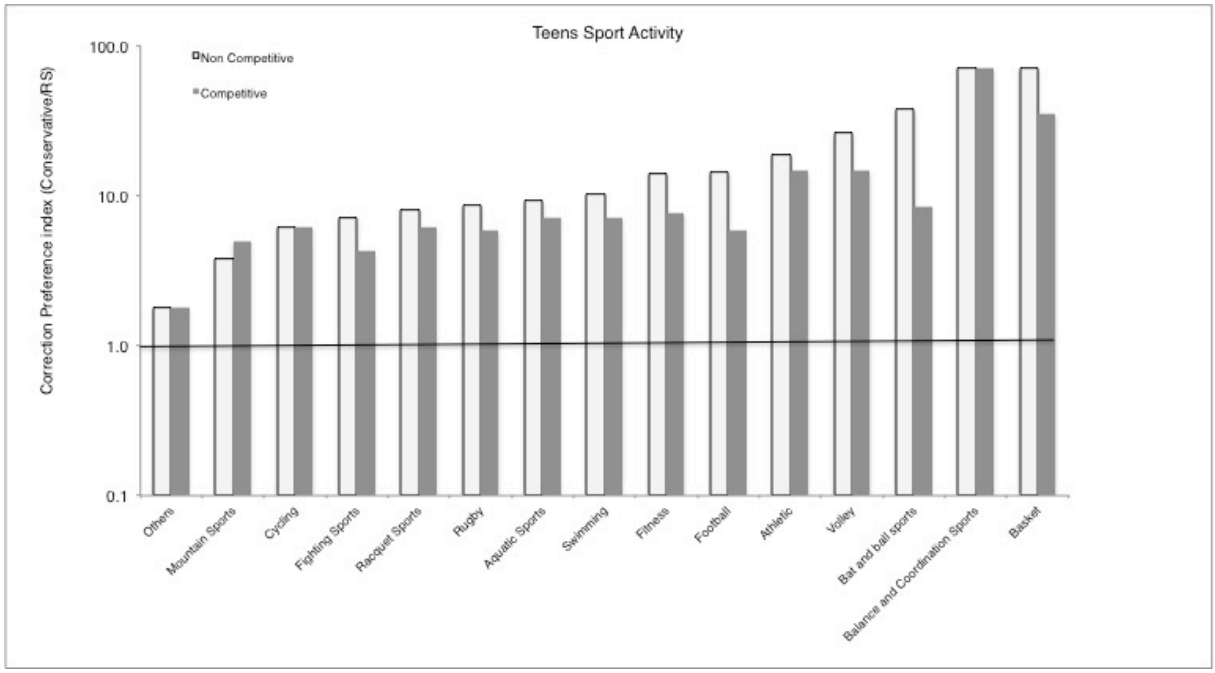

Figure 6: Correction Preference index (Conservative/RS) in different sports for the Teens sport practice scenario.

Index was calculated as the sum of spectacles and CLs preference divided RS preference. A Conservative/RS index of 1 (means that conservative and RS are equally preferred by the interviewees) is marked in the figure by a thicker black horizontal line).

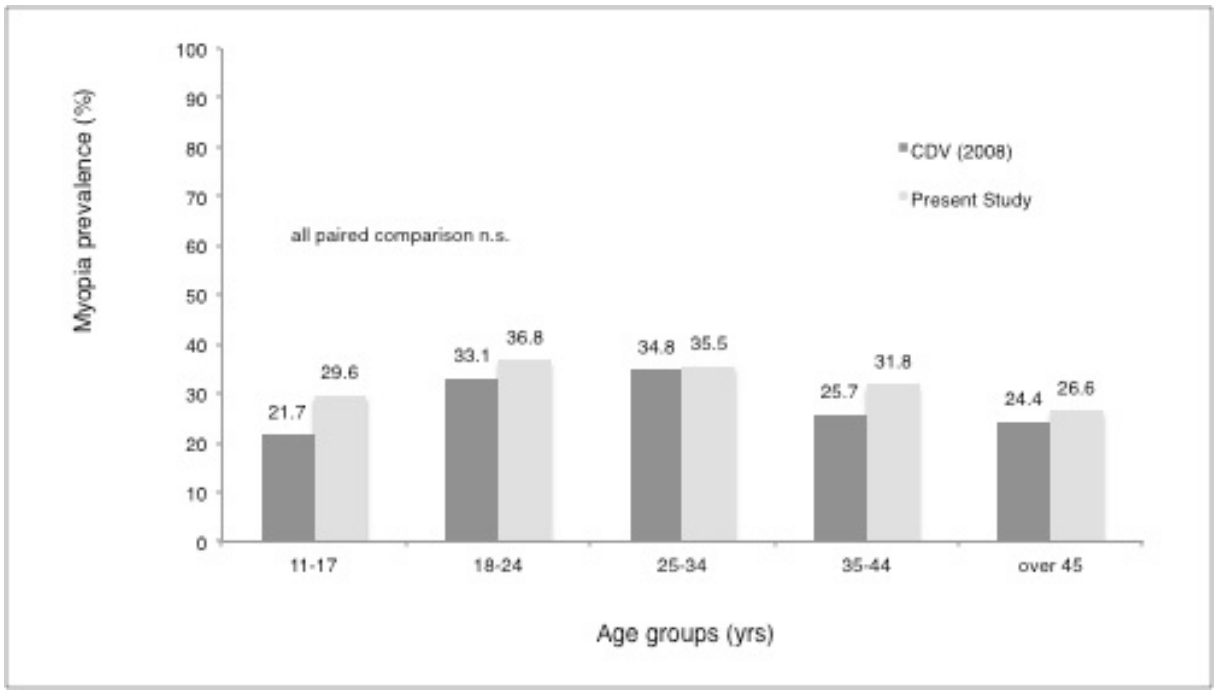

Figure 7: Myopia prevalence comparison between present data and data from 2008 survey.[40] The data in the present study has been recalculated for the overall myopia prevalence on the basis of the age groups used in the 2008 study and on the gender ratio of 0.93 (males/females).