Retraction Notice

Title of retracted article: **The Validation of a Week-Long Questionnaire against Objective Measures of Light Exposure among a Sample of University Students**

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Editor guiding this retraction: Dr. Pinakin Gunvant Davey (EiC of OJOph)

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The Validation of a Week-Long Questionnaire against Objective Measures of Light Exposure among a Sample of University Students

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Abstract

Aim: To validate the subjective process of measuring the exposure to sun light during daily routine activities, against objective method and find out the feasibility of using light data loggers against the already used method of questionnaire. Methods: 48 masters of orthoptics students from university of Sydney. The subjective measurement gathered by questionnaire for one week-long daily routine activities was compared with the objective measurement obtained by light meter from the same individual. Focus group was to investigate the feasibility of light meter and questionnaire. Results: The mean percentage agreements between questionnaire and light meter without travel were 89.22% ($P < 0.0001$), which was significant and better than chance. The mean percentage agreements for travel only were significant lower (60.11%, $P < 0.0004$). The indoor measures excluding travel by light meter had statistically significantly lower hours count than the questionnaire by around 2.46 hours ($P = 0.0001$). On the contrast, outdoor measures excluding travel for hours count and by light meter were significantly higher than the questionnaire by around 2.79 hours ($P = 0.0000$). Significant correlations were observed between the questionnaire and objective measurement by light meter for outdoor travel (ICC > 0.7; $P < 0.001$), indoors excluding travel (ICC > 0.8, $P < 0.0001$), indoors travel only (ICC = 0.427, $P = 0.001$), outdoor excluding travel (ICC = 0.475; $P < 0.001$) and outdoors (ICC = 0.461; $P < 0.001$). Conclusions: The results of percentage agreement analysis suggested that, the subjective measurement by questionnaire was strongly agreed with objective measurement by light meter for a week-long daytime normal routine activities excluding travel while it was moderately significantly correlated to light meter when travels were measured only. Therefore, light meter could be used as a validate tool for estimating outdoor time spending in Australia according to the light intensity detected. However, the feasibility of light meter in practical is still restricted by the cost issue, complication of wearing light meter and less explanation of the activity. Further areas of research could be administration

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of light meter to assess outdoor time spending over four periods of time.

Keywords

Light Meter, Myopia, Questionnaire, Outdoor Time Spending, Light Exposure

1. Introduction

Myopia, known as short-sightedness, is a refractive defect of the eye in which light generates the images focus before the retina when there is no accommodation. Nowadays, the prevalence of myopia in East Asian cities, such as Singapore, Hong Kong and Taiwan, was increased to more than 20% in primary students and caused more than 80% of young adult [1]. High levels of myopia are associated with increased risk of other visual impairment. Hashemi and his colleagues pointed out that there was a significant high percentage of myopia in these people with nuclear and posterior subcapsular cataract [2]. Moreover, the blue mountains eye study also showed that glaucoma was higher by 4.2% of eyes with low myopic than nonmyopic eyes [3]. Myopia could also have significant costs for optical correction [4]. Therefore, level of concerns about developing myopia is increasing.

The prevalence of myopia for children was significantly lower than peers with the same ethnicity but lived in other countries [5]. Therefore, Rose suggested that the dramatic rise in the prevalence of myopia in East Asia would be due to the dramatic environmental change, such as urbnnization [4]. On her further study, she found that the prevalence of myopia in Sydney was lower than Singapore, which was due to the increased hours of outdoor activities [1]. Similarly, Ip and his colleague found that the prevalence of myopia in inner city urban areas was higher than outer suburban areas would suggest that environment, not ethnicity, near work, or parental myopia, were also playing an important role in the development of myopia [6].

Cohen *et al*. found that higher rates of myopia in school children had low exposure to outdoor activities than these with high exposure, which suggested an association of axial myopia with light [7]. Ashby *et al*. examined the impact of light intensity on the development of chicken's emmetropization process and found that light intensity was involved in the chicken's emmetropization as the chicks under high-light intensity had less myopic refractions compared with chicks under normal light levels [8].

Recently animal studies revealed that light intensity played an important role on the development of chicken's emmetropization process [7]. Under light-dark cycles, most chicks under low or medium light intensities (50 and 500 lux respectively) obtained myopia while no chicks under high intensity (10,000 lux) exhibited myopia [7]. Cohen and his college explained that light could regulate the activity of specific neuromodulator which was involved in the regulation of ocular growth [7] [8]. This neuromodulator is known as dopamine, which acts as an inhibitor of ocular growth and then controls the axial length [7] [8].

The role of outdoor activity has been investigated in the large population-based studies of children in Sydney. Rose and her colleagues found that the higher level of outdoor activity was associated with lower level of myopia in the 12-year-old students [1]. This means more time spending outdoors, including sports or passive leisure activities, which were highly correlated to less myopia development [1]. There were no associations between indoor sport and myopia [1]. Therefore, outdoor activity could be used as a protective strategy against the development of myopia.

According to these data, Dirani and his colleagues have also been working in the large population-based studies of teenage children (1249 participants) in Singapore to investigate the relationship of outdoor activities and myopia in Singapore teenage children [9]. They proved that a greater number of hours spent in outdoor activities by teenage children were protective strategy for the progression of myopia [9]. However, for the clinical importance, to determine how many hours of outdoor activity are significant in preventing the onset or progression of myopia, is still quite challenged due to methodological limitations. Most of previous studies used questionnaire to obtain the amount of time spent outdoors, which would be underestimated by recall bias [9]. The light data logger can objectively record light intensity, which can increase the accuracy of the results. However, another issue arises. It largely increases the cost of the project, and light levels would be various to different areas or different days. Therefore, these difficulties need to be investigated in a well-designed study to find out the feasibility of using light data loggers against the already used method of questionnaire.

The aim of this study is to validate the subjective procedure of measuring the exposure to sun light during daily routine activities, against objective method. The subjective measurement is carried out by questionnaire while the objective measurement is gained from light meter device. This study could help us to determine whether the unmatched results between light data logger data and diary data in Singapore are due to recall bias or error. In this study, well-educated and independent master of orthoptic student will be able to complete their own daily diary accurately, so the hypothesis would be that the light data logger will be moderate to strongly correlate to week-long diary.

2. Method

2.1. Study Participants

Participants who enrolled in ORTH5041 research project 2 were recruited from e-learning site. 48 masters of orthoptics students agreed to participate this project (100%). This group of students was chosen as they were well educated and understood the importance of being accurate in their attribution. 48 attended the focus group between the August 2011 and October 2011. All participants were informed verbally as well as in the participant information statement that they have the right to withdraw from this participation at any time. Ethical approval for the study was granted by the university of Sydney ethics committee and all participants provided written informed consent. The measurement starts after signing the consent form.

2.2. Objective Measurement of Light Exposure

The objective measurements of light exposure were obtained over one week using Hobo light meters. It also was known light data logger, which was made by Onset Computer Corporation. The model used for this project was UA-002-64. It was very light, only 18gram, small (58 × 3[illegible] × 23 mm) and waterproof. It can measure temperature and light and was used to record light intensity in lux every 2 minutes. The light data logger was worn during the waking hours over a week period. One light data logger was put outside and used as control to find out the time of sunrise and sunset. The light intensity gathered by light meter below 1000 lux was discarded and all above was considered as outdoor daytime data. 38.4256 lux was considered as travel indoor and 114.9723 was considered as outdoor travel. The unit of time was transformed from minutes to hours via dividing 30 as light meter recorded every 2 minutes. Then time spending outdoor, indoor, outdoor travel or indoor travel was calculated. The light data logger was required to pin to their outer clothing with the light meter and temperature sensor facing outside all the time. It was required to wear all the time during waking hours.

2.3. Questionnaire

The questionnaire was designed to collect data for one week period, regarding to the time spending in each daily routine activity. It was a diary for the whole 24 hour time and period for all seven days. About 12 activities were coded and one bland was left for participants to specify the activity. For example, travelling in the bus was coded as 9 and travelling in the car was coded as 10, outdoor sports were coded as 4 and sleep was coded as 3, etc. The starting time and ending time were required to record for each activity and there was no gap between them. The indoor and outdoor were also needed to clarify for each activity. All subjects were encouraged to record their activities as more accurate as they can.

2.4. Focus Group

This focus group contains around 10 students and 1 researchers and discussion was focus on any observations, concerns or inconveniences they might meet regarding to complete the diary or wear the data logger. The focus group were conducted by the same interviewer (Amanda) at the end of one week-long measurement. It lasted around one hour for each focus group. All participants had answered focus group questions which were either structured or unstructured. Structured questions included "did you encounter any problems with wearing the light meter?" or "did you wear the light meter every day?" etc. Unstructured questions included "where did you keep the light meter when you were not wearing it?" etc. The focus group questions contained three parts. First part was about the problems for the participants when they were wearing the light meter. Second part was about the problems of filling out the questionnaire. The last part was general discussion, which was for any problems the participant concerns or inconveniences they might meet regarding to complete the diary or wear the data logger.

2.5. Statistical Analysis

All data obtained from light meter or questionnaire will be downloaded into the computer. Each subject was assigned a deidentified ID number by the researcher s so no subjects will be identified through the discrimination data. Then data from subjective method (questionnaire) and objective method (light meter) will be statistically analysed using a paired t-test. Complex analysis was computed in SPSS version 19 and IBM statistical system. Intraclass correlation coefficients (ICC) were used to determine any associations between the objective measurements of time spending outdoor excluding travel, indoor excluding travel, in door travel only and outdoor travel only, and the corresponding questionnaire gathered measurements. Bland-Altman was also plotted by the difference between the two measurements as a function of the average of the two measurements of the study participants.

3. Results

In total, 5 male, 42 female participated for this project (after excluded one female as there was no data obtained from her). All participants attended for the focus groups, which lasted for around one hour. Mean age of men was the same as women (23 years old) while the range for women's age was quite larger than men's (21 - 41 versus 22 - 27). The percentage agreement between questionnaire and light meter were summarized by different status in **Table 1**. The mean percentage agreements between questionnaire and light meter without travel were 89.22% ($P < 0.0001$), which was significant and better than chance. The mean percentage agreements for travel only were significant lower ($P < 0.0004$), which was less matched between light meter and questionnaire. There was significant difference between the mean percentage agreements of measuring travel only and measuring without considering traveling ($P < 0.0001$). The mean non-travel percentage agreement between light meter and questionnaire was significant higher than the mean travel only percentage agreement. Objective measurement by light meter significantly agreed with subjective measurement by questionnaire on all indoor activities, regardless whole week, weekday or weekend ($P < 0.0001$ for all). On the contrast, all outdoor activities recorded by questionnaires were not significantly matched to the objective recording by light meter without considering travelling (whole week outdoor $P = 0.0684$, weekday outdoor $P = 0.1571$ and weekend outdoor $P = 0.9069$).

Excluding travel, the mean indoor hours count measured by light meter or questionnaire for the week were significant lower than for weekend, by averaged 1.32 hours and 1.33 hours respectively (all $P = 0.0000$). There were no significant differences between week and weekend of the mean outdoors hours count excluding travel, which measured by light meter or questionnaire. Light meter measurements for indoor hours count excluding travel were significantly lower than questionnaire, regardless week or weekend (0.35 hours, 0.39 hours respectively). On the other hand, Light meter measurements for outdoor hours count excluding travel were significantly higher than questionnaire, regardless week or weekend (0.38 hours, 0.51 hours respectively).

Table 1. Comparison of mean percentage agreement between questionnaire and light meter, among different situations.

(Percentage agreements)	Mean	95% Confidence Interval for mean	The significance level
Non-travel	89.229	87.238 - 91.22	$P < 0.0001$
Travel only	60.11	54.749 - 65.471	$P < 0.0004$
Non-travel vs. travel	29.119	23.55 - 34.688	$P < 0.0001$
Whole week indoor	93.648	92.417 - 94.879	$P < 0.0001$
Whole week outdoor	55.873	49.537 - 62.208	$P = 0.0684$
Weekday indoor	93.322	92.002 - 94.64	$P < 0.0001$
Weekday outdoor	54.996	48.005 - 61.988	$P = 0.1571$
Weekend indoor	94.268	92.218 - 96.319	$P < 0.0001$
Weekend outdoor	49.422	39.484 - 59.359	$P = 0.9069$

Figure 1 showed that about 13 participants obtained 95% agreement between questionnaire and light meter without considering travel. Without considering travel, the percentage agreement between questionnaire and light meter obtained from most participants were from 78% to 98%. On the contrast, **Figure 2** indicated that the range of percentage agreement between questionnaire and light meter for travel only was from 38% to 85%. On other word, overall percentage agreement between questionnaires and light meter for travel only was obviously lower than when without considering travel.

25 participants had myopia (range −1.00D, −8.5D) and 22 participants were normal. The paired t-test on the appendix (**Table A1**) showed that there were no significant difference between the myopic or non-myopic participants on daytime activity level which recorded by either subjective questionnaire or objective light meter, regardless indoor or outdoor or indoor travel or outdoor travel.

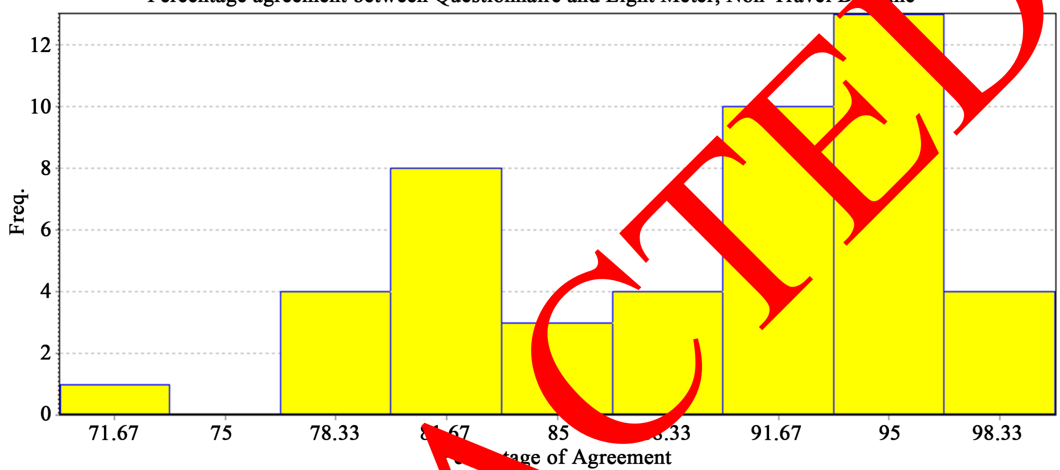

Figure 1. The distribution of percentage agreement between questionnaire and light meter without testing travel and only daytime.

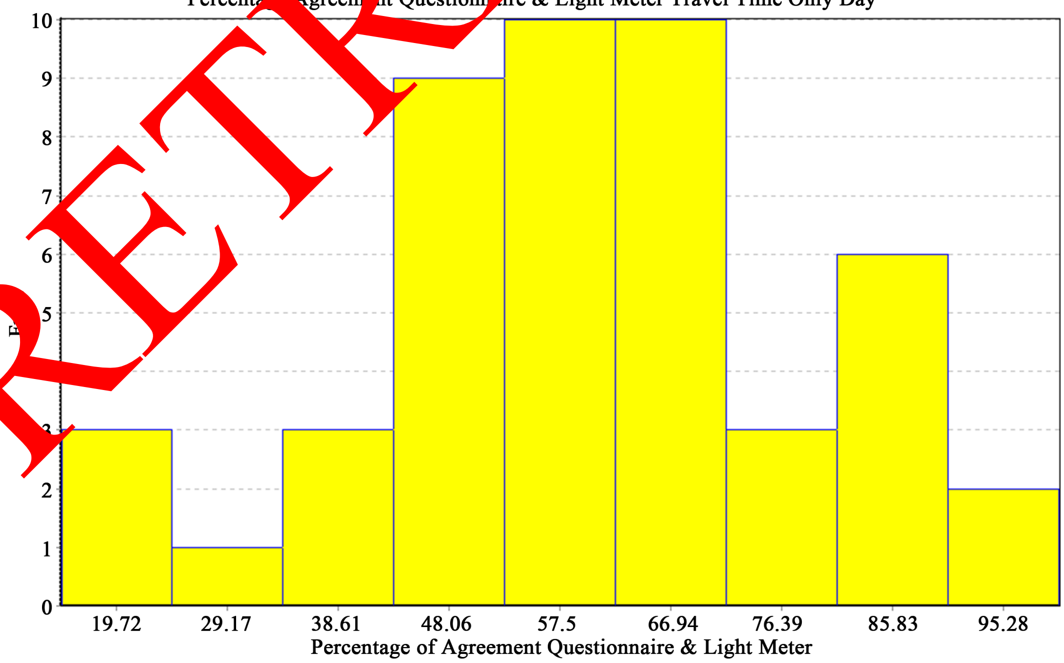

Figure 2. The distribution of percentage agreement between questionnaire and light meter only testing daytime travelling.

Table 2 summarised the average hours count between the questionnaire and light meter in different situations. The indoor measures excluding travel by light meter obtained statistically significantly lower hours count than the questionnaire by around 2.46 hours ($P = 0.0001$), which was also supported by Bland-Altman plot (**Figure 3**) that the average of the difference between questionnaire and light meter for indoor hours count excluding travel was close to 2.46 hours and most of the differences were positive. Moreover, the hours count for outdoor travel only measured by light meter were also statistically significantly lower than the questionnaire by around 1 hours ($P = 0.0015$), which was also supported by **Figure 4** that most of differences were positive. On the contrast, outdoor measures excluding travel and indoor travel only by light meter were significantly higher hours count than the questionnaire by around 2.79 hours ($P = 0.0000$) and 0.99 hours (0.0015) respectively, which were also supported by **Figures 4-6**.

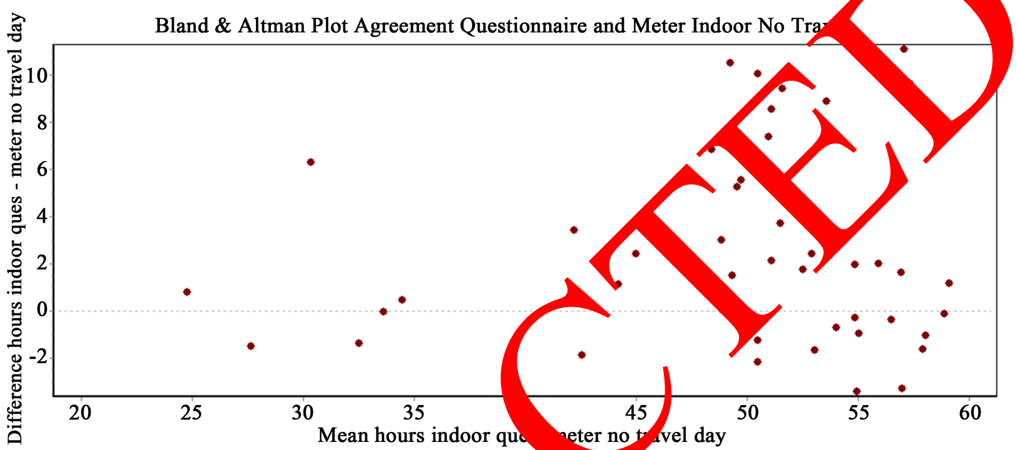

Figure 3. Bland and Altman plots displaying the difference between questionnaire and light meter for indoor hours count excluding travel against mean indoor hours count of questionnaire and light meter.

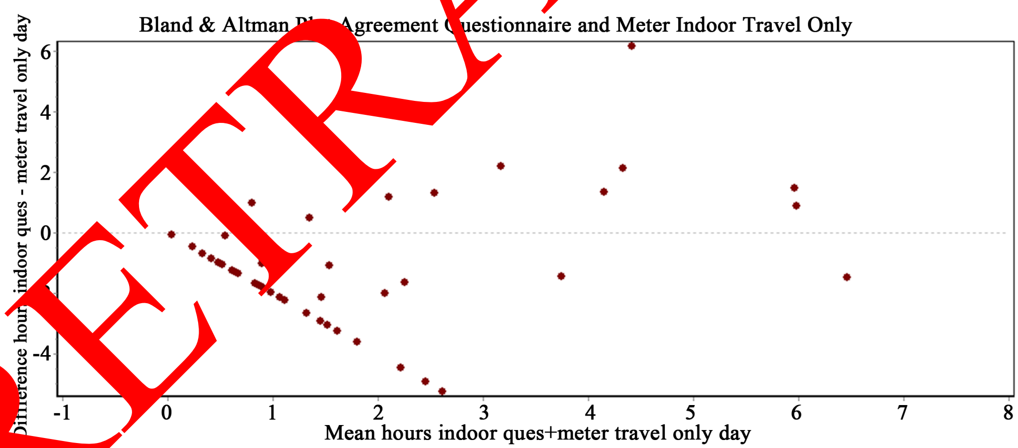

Figure 4. Bland and Altman plots displaying the difference between questionnaire and light meter for indoor travel only against mean indoor travel of questionnaire and light meter.

Table 2. Comparison of average hours count between the questionnaire and light meter.

Questionnaire vs. light meter	Mean	The significance level
Indoor no travel	2.46 hours	0.01%
Outdoor no travel	−2.79 hours	0.00%
Indoor travel only	−0.99 hours	0.15%
Outdoor travel only	0.99 hours	0.15%

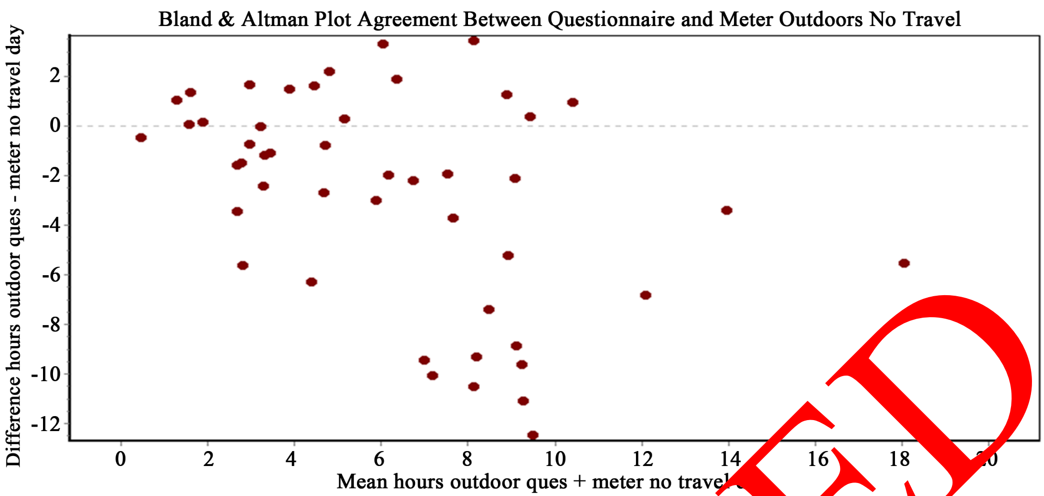

Figure 5. Bland and Altman plots displaying the difference between questionnaire and light meter for outdoor hours count excluding travel against mean outdoor hours count of questionnaire and light meter.

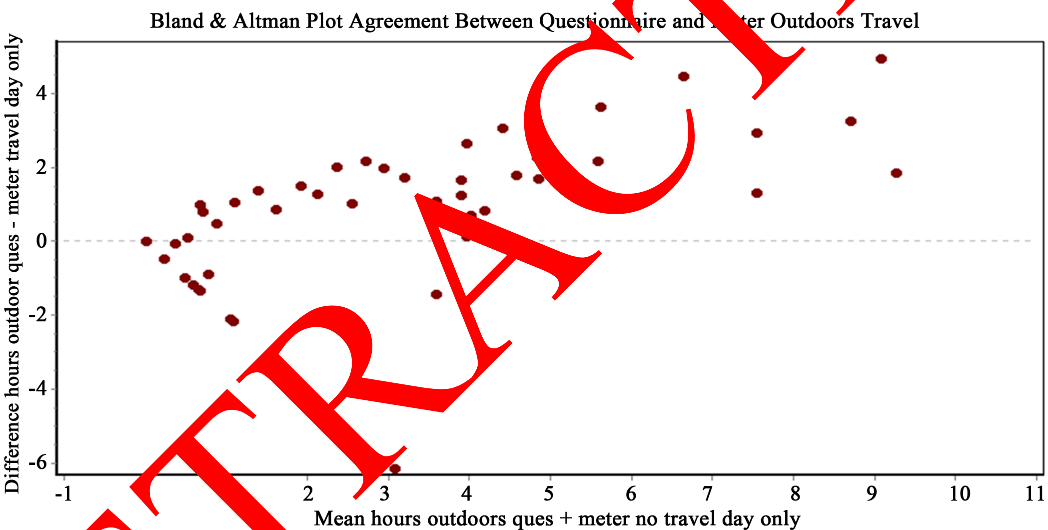

Figure 6. Bland and Altman plots displaying the difference between questionnaire and light meter for outdoor travel only against mean outdoor travel only of questionnaire and light meter.

Table 3 showed that agreement between the measurement of light meter and questionnaire on daily activities agree better than chance in indoors excluding travel, indoors travel only, outdoor excluding travel, outdoor travel and all outdoors, but not in all indoors including travel. Outdoor travel did the questionnaire achieve acceptable agreement with the light meter (ICC > 0.7), and the agreement in indoors excluding travel was good (ICC > 0.8).

4. Discussion

This study is the first to validate the subjective measurement of light exposure during daily routine activities by questionnaire, against objective method by light meter. Our results suggested that questionnaire estimates of light exposure during daily routine activities excluding travel were significantly strongly validate with objective light exposure measurement by light meter on the same time period (the mean percentage agreement is 89.22%, $P < 0.0001$). For measuring travel only, the subjective measurement via questionnaire was significantly but moderately matched with objective light meter (the mean percentage agreement was 60.11%, $P < 0.0004$). Significant correlations were observed between the questionnaire and objective measurement by light meter for

Table 3. Intra-class correlation between questionnaire and light meter for measuring various types of activities.

Comparison to light meter	Intra-class correlation	*P*
Indoors no travel	R = 0.892	$P < 0.0001$
Indoors travel only	R = 0.427	$P = 0.001$
All indoors	R = −0.023	$P = 0.56$
Outdoor no travel	R = 0.475	$P < 0.001$
Outdoor travel	R = 0.738	$P < 0.001$
Outdoors	R = 0.461	$P < 0.001$

outdoor travel (ICC > 0.7; $P < 0.001$), indoors excluding travel (ICC > 0.8, $P < 0.0001$), indoors travel only (ICC = 0.427, $P = 0.001$), outdoor excluding travel (ICC = 0.475; $P < 0.001$) and outdoors (ICC = 0.461; $P < 0.001$). Therefore, the light meter was moderately to strongly correlate to questionnaire and it can be used to significantly estimate the sun light exposure according to their daily routine activities in the past.

No significant agreement were observed between objective and self-reported measurement of outdoor activities excluding travel, regardless testing the whole week outdoor activities, weekday outdoor activities or weekend outdoor activities only. This could be due to the issues of using light meter. Light meter will classify the activity of sitting next to the window as outdoor activity according to the high level of light intensity detected, whereas the participants recorded it as indoor. Therefore, the light meter would tend to overestimate outdoor hours count, which is supported by the data from Table [illegible] that outdoor measures excluding travel by light meter were significantly higher hours count than the questionnaire by average 2.79 hours ($P = 0.0000$). The comparison between light meter and questionnaire for mean indoor hours count and outdoor hours count both excluding travel demonstrated that overall the light meter tended underestimate indoor hours.

Excluding travel, light meter and questionnaire both agreed that the mean indoor hours measured for the week was significant lower than weekend (all $P = 0.0000$). However, there were no significant differences between week and weekend of the mean outdoors hours count excluding travel, which measured by light meter or questionnaire. The significant increased mean indoor hours count for weekend indicates the university students tend to spend more time indoor than weekday.

The percentage agreement analysis indicated that overall match between questionnaire and light meter for travel only was moderately significant (60.11%, $P < 0.0004$), which was much lower than the measurement on all excluding travel (89.[illegible]%, $P < 0.00$[illegible]). This decreased inaccuracy may be explained by confused coding travels as indoor or outdoor by participants. The potential inaccuracy of the objective measurement of light exposure might also provide an alternative explanation. The light sensor of light meter to detect light exposure was easily blocked by arms or seat belt when drive in the car.

The myopic or non-myopic participants were compared on outdoor activity level. However, there were no significant differences found on outdoor hours count between them. According to Rose's finding, more times spending outdoors, including sports or passive leisure activities, are highly correlated to less myopia development [illegible], the participants with myopia would tend to have less time spending outdoors than normal. This discrepancy could be explained by changes in daily routine activities for the study participants due to recording. The participants would not like to record their sleeping habits or tend to increase the outdoor time spending.

There are several limitation should be considered for this study. The generalisability of our finding to different study populations would be questioned when using questionnaire in future studies. Factors to consider include differences between participants and non-participants and the age distribution of the study population. The age would be an important factor because normal daily activity would be various through the different age groups. All data were collected from the mature master orthoptic students throughout one week-long. Sample sizes were not big enough. Instruments limit and condition of participant would result in that the measurements by objective or subjective method are not feasible to last too long. This week length measurement would be hard to represent the participants' normal daily activity. If the time lengths extend to one year, taking seasonal changes or study vacation into account, data can be collected and comparison in 4 periods (summer vacation, spring (semester work), autumn (semester period) and winter vacation).

It is less likely that there will be perfect agreement between subjective measurement by questionnaire and

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Table 4. Comparison of mean hours count between the questionnaire and light meter for week and weekend.

	Mean difference	95% Confidence Interval for mean	The significance level
Light meter: indoors week no travel vs weekend no travel	−1.3235	−1.8707 - (−0.77625)	*P* = 0.0000
Light meter: outdoors week no travel vs weekend no travel	−0.21967	−0.56315 - 0.1238	*P* = 0.2036
Questionnaire: indoor week no travel vs weekend no travel	−1.3341	−1.8675 - (−0.80074)	*P* = 0.0000
Questionnaire: outdoor week no travel vs weekend no travel	−0.13016	−0.44238 - 0.18205	*P* = 0.4045
Light meter indoors week no travel vs questionnaire indoors week no travel	−0.35461	−0.54286 - (−0.16636)	*P* = 0.[illegible]04
Light meter outdoors week no travel vs questionnaire outdoors week no travel	0.38298	0.18332 - 0.58264	*P* = 0.[illegible]004
Light meter indoor weekend no travel vs. Questionnaire indoor weekend no travel	−0.39472	−0.735 - (0.[illegible]43)	[illegible] 0.0241
Light meter outdoors weekend no travel vs. Questionnaire outdoors weekend no travel	0.5061	0.20[illegible]37 - 0.80882	*P* = 0.0016

objective measurement by light meter, because the questionnaire documented currently daily routine activity, which can give more details of the activity, whereas light meter only record the correlated temperature and light intensity, which has less sensitivity than questionnaire. The feasibility for light meter would be restricted to do cohort study over a long period. Firstly, light meter tends to overestimate the outdoor time spending as it defines high light intensity as outdoor but sometime the participants are doing indoor activities. Secondly, light meter will increase the cost of the project. Thirdly, complication of wearing light meter over a long period would be challenged by the comments from another people. Fourthly, the light meter records light intensity every 2 minutes, which can improve accuracy by increasing the frequency.

5. Conclusion

This is the first study to demonstrate the validity of subjective measurement via questionnaire for a week-long, against objective measurement obtained light meter. The results of percentage agreement analysis suggested that, the subjective measurement by questionnaire was strongly agreed with objective measurement by light meter for a week-long daytime normal routine activities excluding travel (the mean percentage agreement was 89.22%, $P < 0.0001$). The questionnaires were moderately significantly correlated to light meter when travels were measured only. Therefore light meter could be used as a validate tool for estimating outdoor time spending in Australia according to the light intensity detected. However, the feasibility of light meter in practical is still restricted by the cost issue, complication of wearing light meter and less explanation of the activity. Further areas of research could be administration of light meter to assess outdoor time spending over four periods of time.

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Appendix

Table A1. The average total time spending outdoors, indoors or travel of study participants were summarized by objective and subjective measurement in **Table A1**.

	Light data logger (objective)	Questionnaire (subjective)
Mean hours outdoors (hours/person)	All: 7.6 Men: 7.5 Female: 7.6	All: 4.8 Men: 5.3 Female: 4.7
Mean hours indoors (hours/person)	All: 48.2 Men: 47.2 Female: 48.3	All: 50.7 Men: 49.5 Female: 50.[illegible]
Mean hours travel (hours/person)	-	All: 5.1 Men: 6.0 Female: 5.0

Summary of Focus Group Question

All participants attended the focus group and completed the questionnaires. Some people indicated that they had some changes in normal behaviour while reporting, e.g. went outside more, or avoided recording sleeping habits.

Most participants responded with some problems related to wearing the light meter. Some participants forgot to wear the light meter everyday as light meter left on yesterday's clothes. Many participants forgot to wear for a while in the morning after waking and the light meter was left beside table. Most participants responded that the light meter did not fall off or turn around when worn in suggested manner. The arms or seat belt blocked the light meter while some participants were driving. Another people thought the light meter was a tracking device or pager and most participants explained that it was for research project. Most participants generally forgot that the light meter was being worn.

There were some other problems for participants when they were filling out the questionnaire. The time recoded on questionnaire did not exactly match the time on clocks. Short periods of time outside were difficult to record. All participants had coding issue for travel, walking to bus, or street front shopping etc., not sure coding indoors or outdoors. Most participants coded car travel as outdoors. Most participants filled the questionnaire throughout the day while some people filled in at the end of day and sometimes did not remember exact times.