BRIEF REPORT

Use of a novel flipped classroom intervention to increase medical students’ knowledge of physical activity guidelines

[version 1; peer review: awaiting peer review]

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Abstract

Background: It is important medical students, as tomorrow’s doctors, have knowledge of physical activity (PA) guidelines. Previous data suggests only 14.9% of medical students knew adult PA guidelines. This study aimed to assess how a novel flipped classroom intervention impacted undergraduate medical students’ knowledge of PA guidelines and their confidence applying these in clinical practice.

Methods and Results: This study utilised a prospective repeat measures quantitative design to evaluate the educational intervention. Survey results of the intervention group were compared to the comparison group. 45% of students who received the intervention knew adult guidelines, compared to 12% of students who did not receive the intervention ($\chi^2(2, N = 244) = 33.07, p < 0.001$). 39% of the intervention group knew child guidelines, compared to 20% who did not receive the intervention ($\chi^2(2, N = 244) = 10.59, p = 0.001$). The intervention group felt more confident in PA training and asked for less PA training in the future.

Conclusion: The results suggest a flipped classroom intervention had a positive impact on medical students’ knowledge of PA guidelines, and confidence in PA training. Further research is required to assess longer-term impacts of this teaching and follow-up the same year group pre- and post-intervention.

Keywords

preventative medicine, medical education, health promotion, physical activity
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Introduction
Physical activity (PA) is associated with prevention and management of many chronic diseases including obesity, cardiovascular disease, cancer, type 2 diabetes and mental health problems. As a result, effective PA promotion is a public health priority.

Healthcare professionals have an important influence on behaviour of their patients and Sallis suggested PA should be thought of as a medication which is prescribed to patients. To this effect, the World Health Organization’s ‘25 by 25’ goal to reduce global physical inactivity by 10% by 2025 includes PA education in training of healthcare professionals as a key objective in their action plan and in the UK, exercise as a prescription or PA advice for health promotion is included in at least 76 National Institute of Health and Care Excellence (NICE) guidelines and recommendations. This highlights the importance of medical student knowledge of PA.

One way in which doctors can promote PA is through informing patients about government recommendations for PA at each stage of life. Most recently produced in 2019, UK Chief Medical Officers (CMO) guidelines provide a benchmark for PA levels which should be achieved each week to gain associated health benefits. At time of writing, there is no explicit mention of PA in the General Medical Council outcomes for graduates, despite specific mention of nutrition.

To be able to promote PA, medical students, as tomorrow’s doctors, should understand the importance of PA and have knowledge of national guidelines. This would better equip them to provide PA advice with confidence. Despite this, in 2012 only 56% of UK medical schools taught CMO PA guidelines, with PA given an average of 4.2 hours of teaching time compared to 109 hours of pharmacology. More recent data are not available but Scottish medical students’ knowledge of CMO adult PA guidelines appears to be low. In a multiple-choice question with five options, only 68% of 177 final year students could correctly identify adult guidelines. This contrasted to 97% who correctly identified alcohol guidelines. Furthermore, in a 2017 study of medical students, only 14.9% knew PA guidelines for adults, 8.4% felt adequately trained about PA and 91.1% wanted more formal training.

Therefore, interventions to increase medical students’ knowledge of PA are essential. A systematic review of PA counselling educational interventions in medical schools in the United States, United Arab Emirates, Bahrain and Thailand, indicated students’ self-efficacy to deliver PA counselling improved post-intervention. One proposed method for PA educational intervention is the flipped classroom approach. This involves removing traditional structures of the lecture and replacing it with an interactive discussion based on educational resources students work through prior to the session. This approach has been shown to have a number of benefits including increasing material covered in a given time frame, providing a more engaging lecture environment, and learning at a speed that suits individual students. Two recent meta-analyses have shown benefit to this learning method over a conventional classroom for student engagement and achieving learning outcomes.

The overall aim of this study was to assess how delivery of a novel flipped classroom intervention impacted undergraduate medical students’ knowledge of PA guidelines and their confidence applying these in future clinical practice.

Methods
Study objectives

1. How a flipped classroom intervention impacts undergraduate medical students’ knowledge of adult and child PA guidelines.
2. How a flipped classroom intervention impacts undergraduate medical students’ confidence in their PA training.
3. Whether students want more PA teaching in the undergraduate curriculum with or without the flipped classroom intervention.

Study design
This study utilised a prospective repeat measures quantitative design to evaluate the educational intervention. The study population consisted of University of Edinburgh undergraduate medical students, specifically first- and second-year cohorts in 2015/16 and 2019/20 academic years. Students could choose not to participate, and those who completed the questionnaire but did not indicate informed consent (by tick box) were excluded.

Ethical approval was granted by the institutions Research Ethics Committee.

Baseline: In 2015, first- and second-year students were surveyed regarding their knowledge of PA guidelines and their confidence applying these. The baseline data were previously reported.

Intervention: Flipped classroom intervention for first-year students began in February 2017 and was repeated annually.

Follow up: In the 2018/19 academic year (prior to the 2019 delivery to first-years) the survey was repeated in the first- and second-year groups. This meant second-year students had undergone the flipped classroom intervention in the previous academic year (February 2018 (intervention/exposed group)) and the first-year students had not (comparison group).

The flipped classroom intervention is the only formal PA teaching in the medical curriculum, so we assume any observed changes in second-years from the 2015 cohort to the 2019 cohort (relative to the first-years) can be attributed to the intervention. The first-years are unexposed at both time-points and allow for some assessment of any secular or background trends.
Intervention details
The flipped classroom intervention was delivered in pilot (February 2017) and full (February 2018) to first-year medical students. The full delivery (February 2018) was evaluated in this study. The intervention was delivered as part of an existing ‘Health, Ethics and Society’ module, and was the first (and only) PA content on the curriculum.

Six staff members and six undergraduate medical students designed the intervention (developing self-study preparatory materials, the classroom element and case studies). Students were encouraged to engage with preparatory materials before attending the classroom element and further resources were available after the session.

Data collection
Baseline (2015) data collection was conducted using paper questionnaires. A 5-minute presentation was given at the end of an unrelated whole year group lecture explaining the study and the questionnaire. This presentation did not include any educational information about PA or PA guidelines. Students were then asked to complete the questionnaire (12 items) which took <5 minutes. These anonymous questionnaires were collected as students left the lecture.

Follow-up (2019) data collection was also conducted at the end of an unrelated whole year group lecture. The same questionnaire items were used, but Bristol Online Survey was used instead of paper questionnaires. As with 2015, a five-minute presentation explained the study, but the presentation did not include any educational information about PA or PA guidelines. The survey link was shared on a screen in the lecture theatre and students were encouraged to enter the link into their browsers. All students completed the survey independently while remaining inside the lecture theatre. First-year students were followed up in the lecture theatre two months later, in order to maximise the response rate. The survey used can be found in the supplemental online material.

Consent
Participants were asked to read the participant information and indicate informed consent by tick box before completing the questionnaire.

Statistical analysis
Statistical tests were performed using Statistical Package for Social Sciences (SPSS) version 25.0.0.1. Chi-squared tests were used to determine differences in frequency of survey responses between baseline and follow up in the intervention (second-year) and comparison (first-year) groups.

Results
Demographics
In total, 273 students responded in 2015, and 175 in 2019 (Table 1).

### Table 1. Study demographics showing the percentage of eligible respondents who completed the survey.

|                | 2015         | 2019         |
|----------------|--------------|--------------|
| First-years; responses/eligible respondents (%) | 125/205 (61%) | 79/213 (37%) |
| Second-years; responses/eligible respondents (%) | 148/214 (69%) | 96/208 (46%) |

Objective 1 - Knowledge of adult and child PA guidelines

#### Adult aerobic recommendation.
This was assessed as the percentage of students who knew the recommended number of minutes of moderate intensity activity for adults over a week.

Comparison group (first-years): The percentage of students who knew the recommendation was low in both 2015 (13%) and 2019 (9%). The difference between first-year groups was not significant, $\chi^2(2, N = 204) = 0.75, p = 0.39$.

Intervention group (second-years): The percentage of students who knew the recommendation at baseline in 2015 (no flipped classroom) was low (12%) and comparable to the first-year comparison group. In contrast, at follow-up in 2019 (students who had received flipped classroom) it was considerably higher (45%). This difference was significant, $\chi^2(2, N = 244) = 33.07, p = < 0.001$.

#### Child (5-18 years) aerobic recommendation.
This was assessed as the percentage of students who knew the recommended number of minutes of moderate-vigorous aerobic activity recommended for a child over a week.

Comparison group (first-years): The percentage of students who knew the recommendation varied between 2015 (38%) and 2019 (29%). However, the difference between first-year groups was not significant, $\chi^2(2, N = 204) = 1.55, p = 0.21$.

Intervention group (second-years): The percentage of students who knew the recommendation at baseline (no flipped classroom) in 2015 was low (20%). In contrast, in 2019 (students who had received flipped classroom) it was higher (39%). This difference was significant, $\chi^2(2, N = 244) = 10.59, p = 0.001$.

Objective 2 - Confidence in PA training

Comparison group (first-years): The percentage of students who felt adequately trained on PA was low in both 2015 (5%) and 2019 (9%). The difference between first-year groups was not significant, $\chi^2(2, N = 204) = 1.34, p = 0.25$.

Intervention group (second-years): The percentage of students who felt adequately trained on PA at baseline (did not receive flipped classroom) in 2015 was low (6%) and
comparable to the comparison group. In contrast, at follow-up in 2019 (students who had received flipped classroom) it was more than twice as high (20%). This difference was significant, \( \chi^2(2, N = 244) = 10.76, p < 0.001 \).

**Objective 3 - Asking for more training in PA**

Comparison group (first-years): The percentage of students asking for more training on PA was high in both 2015 (93%) and 2019 (91%). The difference between first-year groups was not significant, \( \chi^2(2, N = 204) = 0.18, p = 0.67 \).

Intervention group (second-years): The percentage of students asking for more training on PA at baseline (no flipped classroom) in 2015 was high (89%) and comparable to the comparison group. In contrast, at follow-up in 2019 (students had received flipped classroom) it was notably lower (71%). This difference was significant, \( \chi^2(2, N = 244) = 13.27, p < 0.001 \).

Table 2 shows overall responses to each of the study objectives.

**Discussion**

**Principle findings**

The results suggest the flipped classroom intervention had a positive impact on medical students’ knowledge of adult PA guidelines. 2.5 times more students were able to recall correct adult PA guidelines following the intervention. The impact on knowledge of child PA guidelines was less clear due to large differences at baseline.

The intervention had a positive impact on students’ feelings about adequate PA training. The proportion who felt adequately trained was nearly three times higher after the intervention, but still relatively low (1 in 5 students). The comparison group did not change.

Students who wanted more PA training in their curriculum fell to ~70% after the intervention (with no change in the comparison group). This suggests for some students this single session met their need, but demand for more remained high.

**Comparisons to literature**

These findings agree with those of Dacey, Kennedy\(^{10}\), that medical students exhibit a positive response to PA education interventions. The baseline data of this study contrasts to that of Dunlop and Murray\(^{7}\) as a much lower percentage of students knew adult PA guidelines (68% compared to 9-13% in this study). This could be explained by Dunlop and Murray\(^{7}\) using multiple choice questions while this study used a free text box.

### Table 2. Students who knew the adult/child guidelines, felt adequately trained and want more training.

|                                  | First-year students (comparison group) | Second-year students (flipped classroom group, 2019 only) |
|----------------------------------|----------------------------------------|----------------------------------------------------------|
| **Adult guidelines**             |                                        |                                                          |
| Baseline (pre-flipped): Correct in 2015 (n; %) | n=16/125; 13%                           | n=18/148; 12%                                           |
| Follow-up (post-flipped): Correct in 2019 (n; %) | n=7/79; 9%                               | n=43/96; 45%                                            |
| **Child guidelines**             |                                        |                                                          |
| Baseline (pre-flipped): Correct in 2015 (n; %) | n=47/125; 38%                           | n=30/148; 20%                                           |
| Follow-up (post-flipped): Correct in 2019 (n; %) | n=23/79; 29%                            | n=37/96; 39%                                            |
| **Felt adequately trained**      |                                        |                                                          |
| Baseline (pre-flipped): 2015 (n; %) | n=6/125; 5%                              | n=9/148; 6%                                             |
| Follow-up (post-flipped): 2019 (n; %) | n=7/79; 9%                              | n=19/96; 20%                                            |
| **Want more training**           |                                        |                                                          |
| Baseline (pre-flipped): 2015 (n; %) | n=116/125; 93%                           | n=132/148; 89%                                          |
| Follow-up (post-flipped): 2019 (n; %) | n=72/79; 91%                            | n=68/96; 71%                                            |

Note: only 2019 second-years received the flipped classroom intervention.
Baseline results of this study were similar to a study which found only 20% of UK General Practitioners (GPs) were familiar with PA guidelines\(^1\). However, GPs’ knowledge of guidelines was not assessed, rather subjective perceptions of their familiarity. A higher percentage (43%) of GPs felt confident in their PA training\(^1\), in comparison to only 5-20% of medical students in this study.

**Plausible explanations**

The impact on knowledge and training needs may be explained by educational advantages of the ‘flipped approach’. Students were provided with many resources in a short session, in a format which is thought to be more memorable than a ‘traditional’ one-off lecture, therefore making the most of available time. However, with low starting values for knowledge of adult guidelines and feelings of being adequately trained, there is considerable room for improvement. Any PA teaching session may have had a measurable impact and because there was no control intervention, we cannot conclude how effective the flipped approach was, compared to other teaching approaches.

The lack of clear impact on knowledge of child guidelines is likely a function of large differences between comparison and intervention groups at baseline and the large change between baseline and follow-up in the comparison (unexposed) group. This variable may be more noisy in general, perhaps because it is easier to correctly guess (60 mins per day) than the adult guideline.

Desire for more PA content in the curriculum fell but remained high. This is likely explained by a range of existing interest with some students feeling their interest was met and others still wanting more.

**Implications and future research**

Our results highlight a growing need for increased PA teaching in medical schools. Effectiveness of flipped classroom learning may be even more relevant in the context of increased online learning due to the COVID-19 pandemic.

There was a substantive time difference between delivery of the intervention (February 2018) and follow up (November 2018), but further research is required to assess longer-term impact of this teaching. The study could be replicated in other medical schools or on a national level. Impacts of including PA content on medical school examinations should also be studied. It was not possible to assess the same year group pre- and post-intervention and this should be considered in future research.

**Strengths and limitations**

The novelty of this intervention in an important population is a strength. The study design has high ecological validity as it assesses a real-life educational intervention.

A key limitation of this study was that baseline data collection had a high response rate (61% of first-year and 69% of second-year). This fell at follow-up (37% of first-year and 46% of second-year), so results may be influenced by response bias. Follow-up responses may have been from students who felt confident in PA knowledge, which may have inflated the effect of the intervention. However, it is likely this bias was reflected in all data collection, not just second-years at follow up. The impact of changing from paper to online survey may have contributed to reduced response rate. Paper surveys typically achieve higher response rates than online surveys\(^7\), possibly due to students’ perception that online surveys are less confidential or difficult to use\(^8\).

**Conclusions**

A flipped classroom intervention significantly improved medical students’ knowledge of adult PA guidelines, in comparison to a cohort which did not receive the intervention. After a flipped classroom intervention, students felt more confident in their PA training, but a majority of students still wanted more PA training. Flipped classroom teaching about PA guidelines could be implemented on a national level in order to improve tomorrows doctors’ knowledge about PA and its vast health benefits.

**Data availability**

**Underlying data**

Edinburgh DataShare. Use of a novel flipped classroom intervention to increase medical students’ knowledge of physical activity guidelines, https://doi.org/10.7488/ds/3467\(^1^4\)

This project contains the following underlying data:

- Survey_1_2015_raw_data.csv (Survey responses from the initial pre-intervention paper survey of medical students in 2015.)
- Survey_2_2019_raw_data.csv (Survey responses from the post-intervention online survey of medical students in 2019.)
- Survey_2_2019_coded_data.csv (Coded survey responses from the post-intervention online survey of medical students in 2019.)

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

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