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Validation of Modified SOFIT+: Relating Physical Activity Promoting Practices in Physical Education to Moderate-to-vigorous Physical Activity in 5–6 Year Old Children

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ABSTRACT

To validate the modified System for Observing Fitness Instruction Time to measure teacher practices related to physical activity promotion (SOFIT+) in physical education (PE) amongst 5–6-year-old-children. Participants (n = 162, 53% female, 6.0 ± 0.3 yrs) were recruited from 9 schools. Video-recordings of 45 PE lessons from 9 teachers/coaches were coded using a modified SOFIT+. Accelerometers measured children's moderate-to-vigorous physical activity (MVPA). Validity was assessed via multinomial regression measuring the relationship of both SOFIT+ index score and individual teaching practices with children's MVPA. Inter-rater reliability was examined. A 1 unit increase in the SOFIT+ index was associated with increased likelihood to engage in 10–19 sec, 20–29 sec and 30–40 sec of MVPA, compared to 0–10 sec. Most of the observed teaching practices were significantly related to children's MVPA. Inter-rater percentage of agreement ranged between 88.8% and 99.7%. SOFIT+ is a valid and reliable assessment of teaching practices related to MVPA promotion in PE amongst 5–6-year-old-children.

KEYWORDS

Observation tool; teacher practices; physical education; physical activity; children

Introduction

Across the globe, a significant proportion of children do not meet physical activity (PA) guidelines which advise that children should engage in at least 60 minutes of moderate-to-vigorous PA (MVPA) every day (Janssen & LeBlanc, 2010; Manyanga et al., 2019; Roman-Viñas et al., 2016; Tanaka et al., 2020). This is a concern as low levels of MVPA during childhood are associated with increased likelihood of obesity, metabolic syndrome, poor mental health and lower quality of life (Biddle & Asare, 2011; Poitras et al., 2016; Whooten et al., 2019; Wu et al., 2017). Furthermore, low levels of MVPA in childhood tracks into adolescence and adulthood (Telama et al., 2014). School is an important setting for MVPA promotion as children spend a significant proportion of their time there. Furthermore, for many children, it is the only place where they can participate in organized PA (Chen & Gu, 2018), such as Physical Education (PE) (Hills et al., 2015).

The National Curriculum for PE in England states that primary school children should develop movement competencies enabling them to participate in a wide range of PAs and that children should be taught to master fundamental movement skills, to participate in sport games and perform simple dance movements (UK Government, 2013). Furthermore, the UK Government recently published a plan reporting actions and funds to support the delivery of high-quality PE and PA promotion in schools (UK Government – Department of Education, 2019). International guidelines suggest that children should engage in MVPA for at least 50% of their PE lesson (Pate et al., 2006), whilst also learning movement skills and knowledge about health and fitness that will support PA beyond PE (Hills et al., 2015). PE teachers therefore have a responsibility to support MVPA promotion during lessons (McKenzie et al., 2000; Rutten et al., 2012). Previous research has shown that different teaching practices during PE are positively (e.g., engaging children in game play, proposing partner activities, teacher engaging in PA with children) or negatively (e.g., instructing children, proposing activities requiring waiting time, proposing activities including elimination from the game) associated with children's and adolescent's MVPA levels during lessons (Fairclough et al., 2018; McKenzie et al., 1992; Weaver

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Supplemental data for this article can be accessed on the publisher's website.

et al., 2016). Better understanding of teaching practices is important to help both researchers and practitioners enhance MVPA promotion in PE (Castelli et al., 2013). For this reason, it is important to develop valid and reliable observation tools to assess key aspects of teaching practices that might affect children's MVPA. Furthermore, such tools could be used for process evaluation assessment purposes for academics interested in enhancing MVPA within PE and coaching contexts (Stylianou et al., 2016).

The modified System for Observing Fitness Instruction Time (SOFIT+) is a modified version of the SOFIT systematic observation tool (McKenzie et al., 1992) to assess teaching practices associated with MVPA. SOFIT+ was designed by Weaver et al. (2016) with the aim of providing a more comprehensive assessment of the teaching practices associated with children's MVPA during PE or coaching sessions. Within SOFIT+, Lesson Context variables (e.g., how lesson content was delivered) were kept as in the original SOFIT observation tool, while new variables were added to assess activity context (e.g., how activities were structured), teaching behaviors (e.g., what the teacher was doing) and teacher activity management (e.g., what management strategies were used by the teacher). SOFIT+ has been previously validated in elementary school children from the USA and high school students from the UK (Fairclough et al., 2018; Weaver et al., 2016). To account for gender-specific differences in MVPA engagement during PE or coaching (i.e., boys being more active than girls) and gender-specific attitudes toward different PAs (Peral-Suárez et al., 2020; Tanaka et al., 2018), previous validation studies evaluated the relation between teacher practices and MVPA engagement in boys and girls separately (Fairclough et al., 2018; Weaver et al., 2016). However, SOFIT+ has not been validated in children younger than 6-years-old and amongst primary school children from countries outside the USA, limiting the cross-cultural validity of the tool (Fairclough et al., 2018; Weaver et al., 2016). Furthermore, SOFIT+ was developed to assess teaching practices in line with traditional teacher-centered educational approaches (Weaver et al., 2016). In a traditional PE approach, children have low or no autonomy during lessons and are normally engaged in progressive drills in order to master movement techniques proposed by the teacher (Rudd et al., 2020). Contemporary, child-centered approaches to PE include production teaching styles (i.e., Guided Discovery, Problem-solving, Individual-based choice, Learner initiated, Self-teaching) (Mosston & Ashworth, 2008) and teaching approaches based on Nonlinear pedagogy (Chow et al., 2011) that are not yet investigated in SOFIT+. In nonlinear pedagogy, the role of physical educators is to design learning experiences using a set of constraints which can channel learners' movement skill development while learners have higher levels of autonomy and are free to experiment and find movement solutions that best answer their individual needs (Chow & Atencio, 2014; Rudd et al., 2020). Nonlinear pedagogy fosters higher motivation toward participation in PE compared to traditional approaches and therefore is considered a promising strategy for PA promotion (Moy et al., 2016). A typical characteristic of PE lessons with child-centered approaches is for the teacher to engage in one-to-one or small group interaction with children to help them in their personal and unique learning process (Mercier, 1993). Thus, it is important to assess how these nonlinear and child-centered teaching practices might be associated with MVPA participation. Furthermore, previously validated SOFIT+ tools (Fairclough et al., 2018; Weaver et al., 2016) did not assess the association between management practices during PE lessons and MVPA (i.e., Freezing, Retrieving equipment from multiple areas, Retrieving equipment from one area, Grouping, Interruption Public, Interruption Private). Therefore, the examination of how management practices might promote or hinder MVPA participation in children requires investigation.

The present study therefore aimed to (i) validate the SOFIT+ tool for use in 5–6 years old children within a UK population, (ii) to revise the SOFIT+ tool to integrate aspects of child-centered teaching practices that might be associated with MVPA and (iii) to evaluate the association between management practices in PE with children's MVPA.

We expect teaching practices to be associated with Children's MVPA in line with the previous SOFIT+ validation study in this age group (Weaver et al., 2016) while we expect teacher-centered teaching practices and management teaching practices to be related with children's MVPA during PE.

Methods

SOFIT+

SOFIT+ was designed to measure teacher practices that promote or restrict children's participation in MVPA during PE lessons (Weaver et al., 2016). The teaching practice variables within SOFIT+ are divided into four categories including Lesson Context (e.g., how the content of a lesson was delivered), Activity Context (e.g., how activities were structured), Teacher Behaviors (e.g., what the teacher was doing) and Activity Management (e.g., what management strategies were used by the

teacher) (for full description, see Supplementary material 1). Teaching practices in the above categories are systematically observed through the SOFIT+ observation tool. The observation protocol is divided into two phases where phase 1 concerns Lesson Context and Activity Context assessment, while phase 2 concerns Teacher Behaviors and Activity Management assessment. Each observation phase lasts 20 sec, divided into 10 sec of observation and 10 sec of coding for a total duration of 40 sec per scan.

For the purposes of this validation study, small modifications were made to the SOFIT+ in order to include contemporary PE teaching practices identified by the research team. A variable called 'Discovery Practice' was added to the category Lesson Context to code time where children were invited by the teacher to explore different movement solutions creatively to meet a task or solve a movement challenge. The inclusion of the 'Discovery Practice' variable was made to recognize "production" teaching styles (Mosston & Ashworth, 2008) and Nonlinear Pedagogy approaches (Chow et al., 2011), which have been proposed to foster motivation toward engagement in PA (Zarazaga Raposo et al., 2020). Discovery practice is distinguishable from skill practice as children are given higher levels of autonomy over their movement task and the instructor/teacher does not necessarily explain or demonstrate specific movements required in the task (Chow & Atencio, 2014; Mosston & Ashworth, 2008). Furthermore, discovery practices can be distinguished from game play as it does not necessarily involve games and the main focus of the activity is exploring different ways of moving or solving movement problems (Mosston & Ashworth, 2008). A variable called 'Large Sided Activity' was added to the Activity Context category to code activities where children were divided in groups of five or more as this type of grouping is typical of team invasion games and could be associated with different levels of engagement compared to activities presenting smaller grouping or whole class activities (Tanaka et al., 2018). 'Supervises' was added within Teacher Behaviors to code for moments where the teacher observes students without interacting with them, as this was not included in previous versions of SOFIT+. Finally, the category 'Instruction' within the Teacher Behaviors category, was divided into three sub-categories comprising: 'Instructs Single Child', 'Instructs Group' and 'Instructs Class'. We proposed this modification as the interaction between the teacher and an individual or a small group can present a different function compared to instructing the whole class and it is typically associated with times where the class is engaged in motor content activities (Dale, 1991; Nicaise et al., 2007). Therefore, instructing a single child or a small group could be associated with higher MVPA engagement compared to instructing a whole class, as the children who are not involved in the instruction could be left free to engage in MVPA promoting activities.

Design, Participants and Settings

This study was conducted as part of the SAMPLE-PE intervention cluster randomized controlled trial (Rudd et al., 2020). The study protocols and procedures were approved by the institutional research ethics committee (Reference 17/SPS/031). Gatekeeper consent was obtained from head teachers at 12 primary schools in North-West of England and informed parental consent and child assent was collected for 360 5–6-year-old children within year 1 classes in each primary school for the cluster randomized controlled trial. Due to time constraints and feasibility issues, a convenience sample of nine schools and a random selection of 50% of children in each class were invited to participate in this study. Nine teachers/coaches provided consent to be observed using SOFIT+ and to be video recorded while delivering PE lessons.

Procedures

Data collection occurred during PE lessons delivered within the SAMPLE-PE cluster randomized controlled trial from February to June 2018. Forty-five PE lessons, including three PE lessons from each of the 15 classes within the nine participating schools, were observed. Children from six intervention schools (10 classes) received PE lessons taught by trained coaches (external providers), while children in the remaining three control schools (5 classes) received their usual PE practice delivered by their school teacher.

Before the start of each lesson observation, researchers randomly selected 50% of the children participating in the research study and fitted an ActiGraph GT9X accelerometer on their non-dominant wrist to capture MVPA levels during PE. If a child was absent or could not participate in PE another randomly selected child was invited to wear an accelerometer. PE lesson start time was recorded by a researcher. The children then participated in their PE lessons, which were video recorded using GoPro Hero 5 video cameras (GoPro, USA), positioned to cover the full teaching area. The PE teachers/coaches wore a microphone during the PE lesson to capture audio recordings of their verbal delivery. The time that the PE lesson ended was

recorded and children subsequently returned their accelerometers to the researchers. The digital video and audio recordings of the PE lessons were saved to University servers for later analysis by trained researchers using SOFIT+.

Physical activity assessment

The accelerometers GT9X ActiGraph were set to record at 100 Hz over 1 second epochs to measure acceleration in a range of ±8 g on *x*, *y* and *z* axes. The acceleration data were downloaded using ActiLife software (ActiGraph, USA) in 1 sec epochs and then exported to .csv format. GGIR package (Van Hees, 2020) from R software version 3.2.5 was then used to extract Euclidean Norm Minus One (ENMO) acceleration from csv. files and to classify time spent in MVPA using age appropriate validated cut-points (Crotti et al., 2020).

Observer training and reliability

Three trained researchers performed all coding of SOFIT+ observations from the video-recordings. As a part of the training process, the researchers read the SOFIT+ manual (the SOFIT+ manual is available on request from the corresponding author of this article), familiarized themselves with the instrument based on methods reported in Weaver et al. (2016) SOFIT+ validation study, discussed and clarified any doubts concerning the SOFIT+ variables, committed this information to memory, and then independently analyzed SOFIT+ training videos of PE lessons not collected as part of this study. After analyzing each video and before analyzing a new one, the researchers discussed and resolved any discrepancies between their coding. In line with previous research (Ridgers et al., 2010), the researchers' training was considered completed once inter-rater agreement reached >80% in each category over three consecutive video-recorded lessons. A total of nine PE lesson videos were analyzed before reaching the established reliability target.

Once the training was completed, the lead author analyzed all the video-recorded PE lessons collected in this study (n = 45) while the other two trained researchers independently analyzed seven randomly selected lessons each for a total of 14 lessons. Subsequently, inter-rater reliability was evaluated between the lead author and the other trained researchers over the 14 randomly selected lessons, corresponding to more than 30% of the lessons collected within this study consistently with previous validation of observation tools (Fairclough et al., 2018; Weaver et al., 2014).

SOFIT+ validity

To assess SOFIT+ construct validity, we evaluated if SOFIT+ variables were associated with children's MVPA, as measured by accelerometry, in the hypothesized directions in line with previous SOFIT+ validation studies (Fairclough et al., 2018; Weaver et al., 2016) also reported in Supplementary material 1. Two methods were used to assess construct validity. The first method concerned the association between a SOFIT+ index and children's MVPA, while the second method concerned the association between each SOFIT+ variable and children's MVPA. The SOFIT+ index was designed to account for the complex nature of PE lessons were both MVPA promoting and MVPA decreasing teaching practices could be observed simultaneously (e.g., a teacher is verbally encouraging PA during an activity that includes waiting and elimination) in line with the idea of teaching practices simultaneity in the classroom (Doyle, 2006). To create the SOFIT+ index, the presence of a MVPA promoting teaching behavior within one of the four categories (i.e. Lesson Context, Activity Context, Teacher Behaviors and Activity Management) was coded as 1 point. Similarly, the absence of any MVPA decreasing teaching practices within these categories of the SOFIT+ was coded as 1 point accordingly to what reported by previous SOFIT+ validation studies (Fairclough et al., 2018; Weaver et al., 2016). Therefore, the SOFIT+ index could range from 0 to 9 within a complete scan (lasting 40 sec).

Statistical analysis

R software version 3.2.5 (R Foundation, www.r-project.org) was used to complete the data analysis and the descriptive statistics calculation. Inter-rater reliability was calculated using percentage of Agreement and Cohen's Kappa, that was defined as poor when lower than 0.00, slight when between 0.00 and 0.20, fair when between 0.21 and 0.40, moderate when between 0.41 and 0.60, substantial when between 0.61 and 0.80 and almost perfect when between 0.81 and 1.00 (Landis & Koch, 1977). To examine construct validity, MVPA levels were classified using age-appropriate cut-points on a second by second basis (Crotti et al., 2020). SOFIT+ teaching practices observations and PA recordings from accelerometers could be matched as researchers reported the start time of each PE lesson while accelerometers recorded time together with acceleration second by second. In other words, each 40 sec of PA

measurement for each child was matched to a time specific SOFIT+ scan within the lesson the children participated in. An MVPA variable representing the number of seconds spent in MVPA within each 40 sec of SOFIT+ scan was created and stratified into four categories: 0–9 sec of MVPA, 10–19 sec of MVPA, 20–29 sec of MVPA, and 30–40 sec and of MVPA. The likelihood of the SOFIT+ index score to predict time spent in 10–19 sec, 20–29 sec or more than 30 sec of MVPA compared to the reference category of 0–9 sec of MVPA was estimated using multinomial regression analysis. Multinomial regression models were also used to assess if individual SOFIT+ variables were associated with time spent in 10–19 sec, 20–39 sec or more than 30 sec of MVPA compared to 0–9 sec of MVPA. To account for different teaching practices being recorded within the same SOFIT+ scan, we fitted multiple SOFIT + variables within two models. We designed a multinomial model to evaluate if Lesson Context, Teacher Behaviors and Activity Management variables were associated with MVPA in children within all SOFIT+ observations. Furthermore, we ran a separate multinomial model to evaluate the association between Activity Context variables and MVPA excluding observations where Knowledge and Management were recorded, as Activity Context variables can only be observed during Motor Content activities (i.e., Skill Practice, Game play, Free Play, Fitness and Discovery Practice). Furthermore, groups of mutually exclusive teaching practices within the same category (e.g., Skill Practice, Game play, Fitness and Discovery Practice) were transformed into dummy variables to be fitted in the models. The analysis for boys and girls was done separately as gender differences were found in children MVPA engagement within PE (Tanaka et al., 2018) and in view of gender-specific attitudes toward different PAs that could affect children's MVPA engagement with girls generally preferring individual sports and activities with and artistic orientation (e.g., dance, gymnastic) and boys preferring team invasion activities and activities with a predominant component of competitiveness (e.g., football, racket sports) (Peral-Suárez et al., 2020).

Results

Audio was not recorded in one of the PE lessons because of technical problems; therefore, a total of 44 PE lesson observations were used for analysis. The final sample included 162 children (86 girls) comprising 52.0% of White British children, 2.7% White other nationality, 12.7% Black, 16.0% Asian, 17.3% of other ethnicities and 64.8% of children from the most deprived deprivation decile. Males presented a mean age of 6.0 (SD = 0.3) years and a mean BMI equal to 16.0 kg/m^2 (1.8 kg/m^2) while females presented a mean age of 5.9 (0.3) years and a mean BMI equal to 16.6 kg/m^2 (1.9 kg/m^2). Due to children being absent from school, not participating in PE or technical issues, 114 (56 girls) participants were assessed over 3 lessons, 32 (24 girls) participants were assessed over 2 lessons and 16 (6 girls) participants were assessed in 1 lesson. The lessons lasted on average 32′07" and 14 (31.8%) of them took place outdoors. Children spent on average 34.8% (11.3%) of the lessons engaged in MVPA. The main PE contents of the lessons were ball games (4), dance (10), gymnastic (10), object control (11), relays/obstacle courses (5) and tag games (4).

Results for inter-rater reliability concerning SOFIT+ training can be found in Supplementary Material 1 with an average percentage of agreement of 95.8% comprised between 82.2 and 99.7 and average a Cohen's Kappa equal to 0.76 comprised between 0.25 and 0.98 meaning that reliability was fair to almost perfect. The inter-rater reliability concerning the data collected in this study can also be found in Supplementary Material 1 and involves an average percentage of agreement equal to 95.3% comprised between 88.8% and 99.7% and an average Cohen's Kappa equal to 0.70 comprised between 0.25 and 0.97 meaning that the reliability was from fair to almost perfect.

A total of 2067 SOFIT+ scans were completed (Table 1) with a number of SOFIT+ scans per lesson ranging from 19 to 69. Variables including 'Free Play' (Lesson Context), 'Girls Only Activity' (Activity Context), 'PA as Punishment' (Teacher Behaviors) and 'Retrieving equipment from multiple areas' (Activity Management) were not observed in any lessons. Within Lesson Context, Motor Content (50.2%) was observed in more than half of the SOFIT+ scans followed by Management (28.4%) and Knowledge (21.4%), while Skill Practice (21.4%) made up the largest proportion within Motor Content. As for Activity Context, Individual Activity was observed most often (19.0%), while Elimination Activity (1.0%) was observed the least. Instructs Class (36.0%) was the most commonly observed Teacher Behavior and, together with Instructs Single Child (24.8%) and Instructs Group (13.2%), instruction time represented the vast majority of the Teacher Behaviors. Conversely, Teacher Behaviors associated with Promotes PA (0.2%) and Withholding PA (0.8%) were rarely observed. Lastly, Activity Management variables were present in a small proportion of our observations (i.e., lower than 5%).

The outputs from the multinomial regression models (i.e., odd ratios and confidence intervals) assessing the association between teaching practices and MVPA can

Table 1. SOFIT+ descriptive data.

		Percentage of scans observed during a lesson	Percentage of scans observed during Motor Content
	SOFIT+ Variables	Mean (SD)	Mean (SD)
Lesson Context	Management	28.4 (13.9)	
	Knowledge	21.4 (10.8)	
	Motor Content	50.2 (16.4)	
	Fitness	1.6 (3.6)	3.7 (8.3)
	Skill Practice	21.4 (23.3)	42.0 (44.3)
	Game Play	13.0 (21.1)	29.6 (41.1)
	Free Play	0.0 (0.0)	0.0 (0.0)
	Discovery Practice	14.2 (25.3)	24.6 (42.6)
Activity Context	Individual Activity	19.0 (19.1)	37.3 (36.8)
	Partner Activity	13.5 (19.2)	24.4 (32.7)
	Small Sided Activity	4.1 (8.7)	9.2 (20.6)
	Large Sided Activity	6.3 (20.3)	10.1 (27.8)
	Whole Class Activity	7.3 (10.2)	18.9 (29.5)
	Waiting Activity	5.9 (10.4)	14.9 (26.2)
	Elimination Activity	1.0 (4.8)	2.8 (12.9)
	Girls Only Activity	0.0 (0.0)	0.0 (0.0)
	Children Off Task	5.3 (6.2)	9.2 (10.5)
Teaching Behaviors	Supervises	20.2 (11.9)	23.8 (14.5)
	Instructs Single Child	24.8 (12.9)	34.8 (20.3)
	Instructs Group	13.2 (14.6)	15.0 (17.1)
	Instructs Class	36.0 (13.9)	19.1 (14.5)
	Promotes PA	0.2 (1.0)	0.6 (2.6)
	PA as Punishment	0.0 (0.0)	0.0 (0.0)
	Withholding PA	0.8 (3.6)	1.0 (4.8)
	PA Engaged	3.8 (5.5)	5.5 (7.8)
	Off Task	2.0 (2.5)	1.7 (3.8)
Activity Management	Signaling	4.5 (4.1)	6.4 (6.2)
	Retrieving equipment M	0.0 (0.0)	0.0 (0.0)
	Retrieving equipment O	1.0 (2.0)	0.2 (1.0)
	Grouping	2.3 (2.4)	0.3 (1.1)
	Interruption Public	4.7 (4.1)	2.1 (3.5)
	Interruption Private	3.8 (4.2)	5.5 (7.0)

PA: Physical activity; **M**: Multiple areas; **O**: One area.

Table 2. Association between teaching practices and physical activity in females.

	10–19 s		20–29 s		30–40 s	
	OR	95% CI	OR	95% CI	OR	95% CI
Model 1[a]						
SOFIT+ Index	1.48	1.43–1.52	1.91	1.83–1.99	2.47	2.32–2.64
Model 2[a]						
Lesson Context						
Knowledge[1]						
Management[1]	0.99	0.86–1.14	0.88	0.71–1.08	0.46	0.28–0.76
Skill Practice[1]	2.31	1.97–2.72	4.26	3.47–5.23	5.00	3.35–7.48
Fitness[1]	2.47	1.55–3.95	4.74	2.73–8.21	16.04	7.76–33.18
Game Play[1]	4.49	3.62–5.58	12.89	9.9–16.78	57.93	37.5–89.49
Discovery Practice[1]	2.5	2.03–3.08	4.74	3.67–6.12	8.14	5.5–12.06
Teaching Behaviors						
Instruct Class[2]						
Instructs Single Child[2]	2.04	1.77–2.35	3.53	2.97–4.2	6.06	4.52–8.12
Instructs Group[2]	1.33	1.12–1.57	1.95	1.59–2.39	3.42	2.45–4.78
Supervises[2]	1.7	1.47–1.96	2.47	2.07–2.96	3.78	2.79–5.11
PA Engaged[2]	1.44	1.09–1.89	1.76	1.26–2.46	1.47	0.79–2.73
Off Task[2]	1.7	1.19–2.42	2.29	1.47–3.56	3.02	1.35–6.76
Promotes PA	4.2	0.48–36.76	4.23	0.48–37.17	5.21	0.58–47.05
Withholding PA	0.93	0.46–1.86	1.19	0.61–2.32	1.00	0.42–2.37
Activity Management						
Signaling	2.29	1.76–2.99	3.16	2.37–4.22	1.87	1.2–2.92
Retrieving equipment O	0.91	0.53–1.55	1.99	1.14–3.48	0.83	0.11–6.29
Interruption Public	0.72	0.57–0.91	0.34	0.23–0.51	0.09	0.03–0.29
Interruption Private	1.2	0.89–1.63	1.47	1.08–2.01	1.67	1.15–2.42
Model 3[b]						
Activity Context						
Single Child Activity[3]						
Partner Activity[3]	1.92	1.48–2.49	2.72	2.07–3.57	2.55	1.80–3.61
Small Sided Activity[3]	0.68	0.47–0.98	0.60	0.40–0.90	0.62	0.38–1.01
Large Sided Activity[3]	1.02	0.69–1.49	0.95	0.64–1.42	0.73	0.43–1.23
Whole Class Activity[3]	0.77	0.56–1.04	1.00	0.72–1.38	0.92	0.60–1.41
Waiting Activity	0.65	0.48–0.89	0.39	0.27–0.54	0.19	0.11–0.34
Elimination Activity	0.61	0.21–1.78	0.19	0.06–0.58	0.75	0.28–2.02
Children Off Task	0.85	0.66–1.08	0.68	0.52–0.89	0.60	0.42–0.87

s: Seconds; **OR**: Odds ratio; **CI**: Confidence Interval; **PA**: Physical activity; **O**: One area; [1]: Included in Lesson Context dummy variable; [2]: Included in Teacher Behaviors dummy variable; [3]: Included in Activity Context dummy variable. [a]: Model included Teacher ID as covariate; [b]: Model included Teacher ID, Lesson Context, Teacher Behaviors and Activity Management variables as covariates.

be found in Table 2 for females and Table 3 for males. SOFIT+ index was significantly and positively related with children's MVPA (Tables 2–3). Compared to engaging in 0–9 sec of MVPA per 40s scan, a 1 unit increase in the SOFIT+ index score was associated with an increased likelihood for girls to engage in 10–19 sec, 20–29 sec and 30–40 sec of MVPA. Similarly, for boys, a 1 unit increase in the SOFIT+ index score was associated with an increased likelihood to engage in 10–19 sec, 20–29 sec and 30–40 sec of MVPA.

Table 3. Association between teaching practices and physical activity in males.

	10–19 s		20–29 s		30–40 s	
	OR	95% CI	OR	95% CI	OR	95% CI
Model 1[a]						
SOFIT+ Index	1.50	1.45–1.55	1.91	1.84–1.99	2.53	2.39–2.69
Model 2[a]						
Lesson Context						
Knowledge[1]						
Management[1]	1.00	0.86–1.16	0.85	0.69–1.05	0.66	0.43–1.02
Skill Practice[1]	2.20	1.84–2.64	3.89	3.14–4.82	8.99	6.15–13.13
Fitness[1]	1.78	1.06–2.98	3.58	2.04–6.27	17.41	8.87–34.18
Game Play[1]	4.36	3.47–5.48	8.44	6.46–11.03	57.88	37.76–88.71
Discovery practice[1.]	3.08	2.49–3.81	6.75	5.26–8.66	11.85	8.09–17.36
Teaching Behaviors						
Instruct Class[2]						
Instructs single child[2]	2.01	1.72–2.35	3.48	2.90–4.18	7.60	5.80–9.96
Instructs group[2]	1.28	1.07–1.52	2.20	1.79–2.70	3.45	2.53–4.71
Supervises[2]	1.84	1.58–2.15	2.82	2.35–3.39	4.30	3.25–5.68
PA Engaged[2]	2.05	1.51–2.78	1.59	1.09–2.32	2.48	1.51–4.09
Off Task[2]	1.19	0.81–1.74	1.78	1.13–2.78	2.91	1.46–5.80
Promotes PA	0.45	0.04–5.14	1.56	0.27–9.06	4.07	0.77–21.60
Withholding PA	0.76	0.45–1.27	0.54	0.32–0.92	0.29	0.13–0.63
Activity Management						
Signaling	2.56	1.91–3.43	3.20	2.35–4.37	1.89	1.22–2.91
Retrieving equipment O	1.66	0.96–2.87	2.38	1.32–4.27	1.78	0.51–6.14
Interruption Public	0.68	0.53–0.88	0.30	0.20–0.46	0.09	0.03–0.26
Interruption Private	1.22	0.86–1.72	1.26	0.88–1.79	1.30	0.87–1.93
Model 3[b]						
Activity Context						
Single Child Activity[3]						
Partner Activity[3]	1.94	1.44–2.63	2.77	2.05–3.75	2.87	2.04–4.04
Small Sided Activity[3]	1.65	1.04–2.61	1.00	0.61–1.63	1.68	0.98–2.88
Large Sided Activity[3]	0.94	0.62–1.43	1.07	0.71–1.64	1.16	0.71–1.89
Whole Class Activity[3]	1.00	0.70–1.43	0.94	0.65–1.37	2.03	1.34–3.07
Waiting Activity	0.48	0.33–0.70	0.35	0.24–0.51	0.09	0.05–0.15
Elimination Activity	0.22	0.08–0.66	0.09	0.03–0.27	0.20	0.08–0.51
Children Off Task	0.75	0.57–0.98	0.73	0.55–0.96	0.88	0.63–1.21

s: Seconds; **OR**: Odds ratio; **CI**: Confidence Interval; **PA**: Physical activity; **O**: One area; [1]: Included in Lesson Context dummy variable; [2]: Included in Teacher Behaviors dummy variable; [3]: Included in Activity Context dummy variable. [a]: Model included Teacher ID as covariate; [b]: Model included Teacher ID, Lesson Context, Teacher Behaviors and Activity Management variables as covariates.

The vast majority of the observed SOFIT+ variables were significantly related to children's MVPA (Tables 2–3). During management, both girls and boys were less likely to engage in 30–40 sec rather than in 0–9 sec of MVPA compared to when doing Knowledge activities. All Motor Content variables comprising Skill Practice, Game Play, Fitness and Discovery Practice were associated with higher likelihood for children to engage in 10–19 sec or in 20–29 sec or in 30–40 sec of MVPA rather than in 0–9 sec of MVPA compared to Knowledge.

As concerns Activity Context, during Partner Activity children were more likely to engage in 10–19 sec, 20–29 sec or 30–40 sec of MVPA rather than in 0–9 sec of MVPA compared to Single Child Activity. Girls were less likely to spend 10–19 sec or 19–20 sec in MVPA rather than in 0–9 sec of MVPA during Small Sided Activities compared to when engaged in Single Child Activities. Conversely, boys were more likely to spend 10–19 sec in MVPA rather than in 0–9 sec of MVPA during small-sided activities compared to when engaged in single child activities. Furthermore, boys were more likely to spend 30–40 sec in MVPA rather than in 0–9 sec of MVPA during whole class activities. Waiting Activity, Elimination Activity and Children Off Task were generally associated with lower likelihood for children to participate in more than 10 sec of MVPA compared to 0–9 sec of MVPA. In particular, Waiting Activity presented the lowest odd ratios where girls and boys were 0.19 and 0.08 times as likely, respectively, to engage in 30–40 of MVPA compared to 0–9 sec of MVPA.

As for the Teacher Behaviors, Supervises, Instructs Single Child, Instructs Group and Off Task, were associated with higher likelihood for both boys and girls to engage in 10–19 sec (excluding boys Off Task) or in 20–29 sec or 30–40 sec of MVPA rather than in 0–9 sec of MVPA compared to Instructs Class. Similarly, when the teacher/coach was engaged in PA (PA Engaged) all children were more likely to spend 10–19 sec or 20–29 sec or 30–40 sec in MVPA rather than in 0–9 sec of MVPA. Teacher Withholding PA was associated with lower likelihood for boys to engage in 30–40 sec of MVPA compared to engaging in 0–9 sec of MVPA, while promoting PA had no significant relation with MVPA engagement.

As concerns Activity Management, when signaling was observed both girls and boys were more likely to spend 10–19 sec or 20–29 sec or 30–40 sec in MVPA rather than in 0–9 sec of MVPA. Similarly, Retrieving equipment from one area was associated with increased likelihood for children to engage in 20–29 sec of MVPA. Conversely, Interruption Public was associated with decreased likelihood for both girls and boys to spend 10–19 sec, 20–29 sec and 30–40 sec in MVPA, rather than in 0–9 sec in MVPA. Interruption Private was related with increased likelihood to engage in 20–29 sec and 30–49 sec in girls only.

Discussion

This study aimed to assess the validity of SOFIT+ as an observation tool to assess teaching practices and competencies related with young children's MVPA engagement during PE. Most of the SOFIT+ categories were associated with children's engagement in MVPA and the associations were generally in line with the hypotheses formulated in the first SOFIT+ validation paper (Weaver et al., 2016). The new SOFIT+ variables proposed in this study comprising Discovery Practice, Instructs Class, Instructs Group and Instructs Single Child were associated with MVPA following the direction hypothesized, though no significant association was found for Large Sided Activity. Furthermore, this was the first study to evaluate the association between SOFIT+ Activity Management teaching practices variables and children's PA, finding both positive and negative associations with MVPA where interrupting the class to address misbehaviors presented the strongest negative association with MVPA.

SOFIT+ Reliability

All the observed SOFIT+ categories presented levels of inter-rater reliability with percentage of agreement above 80% and Cohen's Kappa ranging from fair to almost perfect. Free Play, Girls Only Activity, PA as Punishment and Retrieving equipment from multiple areas were not observed in our study and therefore inter-rater reliability could not be assessed. However, inter-rater reliability for Elimination Activity, Girls Only Activity and Retrieving equipment from multiple areas was evaluated within our observers training for this study (Supplementary material 1) and in previous studies (Fairclough et al., 2018; Weaver et al., 2016), while the absence of PA as a punishment was a positive finding that is in line with best practices in PE (Barney et al., 2016).

SOFIT+ validity

As observed in previous SOFIT+ validations (Fairclough et al., 2018; Weaver et al., 2016), an increase in the SOFIT+ index was associated with higher MVPA engagement in children, meaning that the presence of what we classified as MVPA promoting teaching practices together with the absence of MVPA restricting teaching practices was associated with improved MVPA in PE. The strength of the relationship between SOFIT+ index and MVPA increased with increasing length of MVPA bouts suggesting that children were most likely engaged in 30 sec or more of MVPA over a 40s scan when greater MVPA promoting and lower MVPA restricting teaching practices were observed.

Within Lesson Context category, all Motor Content variables were associated with a higher likelihood for children to engage in MVPA compared to Knowledge and Management, and the strength of the relationship increased with increasing length of MVPA bouts, suggesting that all Motor Content categories were positively related to MVPA. Skill Practice was associated with positive engagement in 30–40 sec MVPA in contrast with what was hypothesized and found by Weaver et al. (2016) who classified Skill Practice as a MVPA restricting variable and contrary to Fairclough et al. (2018), Weaver et al. (2016), and Fairclough et al. (2018) used hip-worn GT3X ActiGraph accelerometers and count-based metrics to measure MVPA while wrist-worn GT9X ActiGraph accelerometers and raw accelerations metrics were used in this study. It was reported that hip-worn accelerometers do not adequately capture MVPA during object control skills differently from wrist-worn accelerometers (Sacko et al., 2019) and that GT3X and GT9X accelerometers can lead to different and non-equivalent PA output based on the metrics used (Clevenger et al., 2020). Therefore, it is possible that MVPA was underestimated during Skill Practice object-control activities in Weaver et al. (2016) and Fairclough et al. (2018) studies. Furthermore, in support of our finding, many of the activities observed in the current study during Skill Practice such as catching or throwing the ball, kicking the ball, jumping and engaging in obstacle or locomotor courses were classified as MVPA within the Youth Compendium of PAs (Butte et al., 2018). Skill Practice presented a slightly lower association with MVPA compared to other Motor Content categories that could be explained by the co-occurrence of waiting activities. Game Play was associated with the highest likelihood for children to engage in MVPA followed by Fitness. This finding is consistent with previous SOFIT+ studies (McKenzie et al., 1992; Weaver et al., 2016) and previous research reporting that Game Play is associated with high levels of MVPA (Tanaka et al., 2018; Wood & Hall, 2015). Within our study, Fitness generally consisted of warm-up or cool-down activities that aligned with best practices in PE involving general aerobic activities and flexibility exercise that could have led to lower MVPA engagement compared to Game Play (Faigenbaum, 2007). Discovery practice was associated with increased MVPA levels in children as hypothesized in our study with higher likelihood for children to engage in MVPA compared to Skill Practice but lower likelihood compared to Game Play and Fitness. This is in line with previous literature suggesting that creating conditions for children to be

autonomous could lead to high motivation to engage in PA within PE (Zarazaga Raposo et al., 2020).

Activity Context variables can be observed only during Motor Content; therefore, we evaluated the association between Activity Context categories and MVPA within SOFIT+ scans including Motor Content only (Tables 2–3). Compared to Individual Activity, Partner Activity was associated with higher likelihood for both boys and girls to engage in MVPA while Small Sided Activity was associated with higher likelihood for boys to engage in 10–19 sec of MVPA confirming the results from previous SOFIT validations (Fairclough et al., 2018). Whole Class Activity was associated with higher likelihood for boys to engage class 30–40 sec of MVPA compared to Individual Activity in contrast with previous research (Fairclough et al., 2018; Weaver et al., 2016). This could be due to whole class activities typical of this age group such as tag games being related to high levels of MVPA (Butte et al., 2018). Large Sided Activity did not show any significant association with MVPA promotion compared to Individual Activity. Children Off Task was related with lower levels of MVPA in both boys and girls. This could be because children off-task might engage in a variety of behaviors that could include disengagement or disruptive conduct that could lead to low PA engagement (Goyette et al., 2000; Lyngstad et al., 2016). Waiting Activity, Elimination Activity and Children Off Task were related with lower likelihood in both girls and boys to engage in MVPA in line with what hypothesized and consistently with previous SOFIT+ validation studies.

For Teacher Behaviors, the categories Supervises, Instructs Single Child, Instructs Group, PA Engaged and Off Task were associated with higher levels of MVPA engagement in children compared to Instructs Class. This matched what we expected as children are normally asked to stand still while the teacher is providing instructions to the whole class leading to low MVPA. Conversely, Instructs Single Child and Instructs Group were strongly related with children's increased MVPA engagement, with Instructs Single Child being the strongest predictor of MVPA engagement. The explanation for this finding could be that the children who were not involved in the teacher instruction were engaged in high MVPA levels. This demonstrates the importance to differentiate Instruction time based on the number of children involved as different groupings are associated with different MVPA engagement. Despite being classified as a barrier to PA, teacher Off Task was associated with positive MVPA engagement with similar odds ratios compared to Supervising, suggesting that teachers attended other duties when they were sure that PE activities were under control or that children maintain MVPA engagement even if the teacher is not watching. Conversely, Withholding PA was associated with low levels of MVPA in line with what was hypothesized; however, this was true for boys only and the reason behind it could be that only male children were asked to withhold from PA within this study. Promoting PA had no association with MVPA in children and that could be due to the very low number of observations of this behavior in our study (0.3% of total observations) suggesting more attention should be given to verbal promotion of PA by PE teachers in primary school.

As concerns Activity Management, Signaling (e.g., Teacher tells children to stop an activity and sit down) was positively associated with MVPA engagement however children were more likely to engage in 10–19 or 20–29 sec of MVPA rather that 30–40 sec. The explanation to our finding could be that children were normally engaged in Motor Content activities during the first phase of the SOFIT+ scan before receiving a signal from the teacher to stop as Signaling was recorded in Phase 2 of SOFIT+ scans. Retrieving equipment from one area was associated with higher likelihood for children to spend 20–29 sec in MVPA suggesting that retrieving equipment is related to lower MVPA levels than Motor Content activities. Interrupting the class publicly was associated with decreased MVPA levels in line with what was hypothesized. However, interrupting privately was positively associated with MVPA, and this is consistent with what was found in this study for Instructs Single Child, where interacting with a child did not lead to decrease in class MVPA levels.

Observed teaching practices compared to previous literature

Motor Content was recorded more often (50.2% of the observations) than Management (28.4%) and Knowledge (21.4%) within our study in conformity with previous studies using SOFIT and SOFIT+ in primary school children (Fairclough et al., 2018; Gharib et al., 2015; Kwon et al., 2020; Stylianou et al., 2016; Weaver et al., 2016). Within previous studies using SOFIT and SOFIT+ children spent the highest amount of time in Game Play followed by Skill Practice, Fitness and Free Play while in studies using SOFIT+ Game Play and Fitness obtained the highest percentages (Fairclough et al., 2018; Gharib et al., 2015; Kwon et al., 2020; Stylianou et al., 2016; Weaver et al., 2016). Differently, in this study higher percentages of Skill Practice were observed and Skill Practice presented higher percentages compared to other Motor Content categories. The reason for this could be that data were collected within the SAMPLE-PE project where PE

interventions were aimed at improving motor competence (Rudd et al., 2020). Given that Discovery Practice was included within Motor Content in this study, it is difficult to make a comparison with previous studies.

As concerns Activity Context, Individual Activity (19% of observations) was observed more times than other categories in line with Weaver et al. (2016) study (71.7% of observations) but with lower percentages. Furthermore, lower percentages of elimination activities (1.0% of observations) and waiting activities (5.9% of observations) were observed compared to Weaver et al. (2016) (8.8% of observations for Elimination Activity and 11.2% of observations for Waiting Activity), which is a positive factor for MVPA promotion during PE.

As for Teacher Behaviors, both in our study and the study from Weaver et al. (2016) more than 70% of the SOFIT+ scans included instruction. However, we divided instruction time in Instructs Class (36.0%), Instruct Single Child (24.8%) and Instructs Group (13.2%). The fact that the three teacher instruction targets were observed consistently strengthen the rationale for the inclusion of these categories in the SOFIT+.

Strengths and limitations

This study presented several strengths including, the inclusion of a high amount of PE lessons compared to previous SOFIT+ validation studies, the assessment of the validity concerning management activities that have never been validated in previous research, the use of statistical models accounting for teaching practices happening simultaneously and the use of 1 sec epoch MVPA assessment that best fits the sporadic and variable nature of PA in 5–6 years old children. The main limitation of this study is that we could monitor MVPA levels only in 50% of the participants providing consent to participate in the study because of time and resources constraints. Therefore, we can only infer that the MVPA levels we assessed in our participants are representative of Class MVPA levels. Other limitations are that some of the activities comprising Free Play, Girls Only Activity, PA as Punishment and Retrieving equipment from multiple areas were never observed and that our sample only included 5–6 years old children living in deprived areas of North West England, limiting the generalizability of our results.

Future directions

To facilitate the assessment of validity and reliability of teaching practice assessment, future validation studies should make sure that all teaching practices are observed multiple times during the data collection phase (e.g., by designing PE lessons including specific teaching practices) and should measure PA in most of the children participating in each PE lesson observed. Despite the current version of the SOFIT+ takes in consideration aspects of both teacher-centered and student-centered approaches, future studies should clarify whether teacher-centered or student-centered approaches in PE lead to different MVPA levels in children (Errisuriz et al., 2018; Lonsdale et al., 2013). Furthermore, SOFIT + does not consider the motivational climate created by the teacher during PE that could potentially influence children MVPA engagement in PE. Empowering motivational climates (i.e., teacher support of autonomy, task-involving, relatedness and structure (Duda, 2013)) foster enjoyment, persistence and intrinsic motivation (Duda, 2013). Intrinsic motivation has been found to positively predict MVPA (Gunnell et al., 2016) while fostering autonomy, competence and relatedness (basic psychological needs) has associated positively with MVPA in children within PE (Gunnell et al., 2016). In contrast, disempowering motivational climates (i.e., teacher supports controlling, ego-involving and relatedness thwarting (Duda, 2013)) were associated with increased anxiety, avoidance, and decrease in effort (Duda, 2013), which could lead to lower MVPA. Therefore, we suggest future observation tools could integrate the assessment of teaching practices associated with motivational climate to facilitate a better understanding around how best to support children's MVPA during PE (Van Den Berghe et al., 2014).

Conclusion

This study confirmed that teaching practices are associated with children's MVPA engagement in PE and provide valuable information about how teachers could maximize children's MVPA engagement (e.g., limiting time spent in management activities and class instruction, avoiding or minimizing elimination and waiting activities or engaging in PA activity with children). We suggest that SOFIT+ is a valid and reliable tool to assess teaching practices related to MVPA in primary school children and that the modification made to the observation tool were appropriate for the age group considered in this study. SOFIT+ could be used in future research focusing on PE teaching or coaching behaviors to evaluate common teaching and coaching practices, to help clarify best teaching practices for MVPA promotion and to evaluate PE teaching or coaching interventions in children. Furthermore, researchers or practitioners could use SOFIT+ to assess the effect of teacher trainings on teaching practices associated with MVPA promotion. Lastly, SOFIT+ could be a user friendly and feasible tool

for practitioners to monitor and evaluate teaching practices to increase children's MVPA. Future research should evaluate the association of teacher-centered and student-centered teaching approaches in PE with MVPA while future observation tools assessing teaching practices in PE or coaching should consider to include aspects concerning the motivational climate created by the teachers.

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