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Original article

Health-related fitness knowledge growth in middle school years: Individual- and school-level correlates

Xihe Zhu [a,*], Justin A. Haegele [a], Haichun Sun [b]

[a] Department of Human Movement Sciences, Old Dominion University, Norfolk, VA 23529, USA
[b] Department of Teaching and Learning, University of South Florida, Tampa, FL 33620, USA

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Abstract

Background: Health-related fitness knowledge (HRFK) has been an essential concept for many health and physical education programs. There has been limited understanding and longitudinal investigation on HRFK growth. This longitudinal study examined HRFK growth and its individual- and school-level correlates in middle school years under 1 curriculum condition: *Five for Life*.

Methods: Participants were 12,044 students from 47 middle schools. Data were collected at both individual/participant and school/institution levels. Individual-level variables included gender, grade, and HRFK test scores. School-level variables included percentage of students receiving free and reduced meals (FARM), student-to-faculty ratio for physical education, and school academic performance (SAP). We used hierarchical linear modeling to examine HRFK 3-year growth in relation to individual- and school-level correlates.

Results: The average HRFK score at 6th grade for females was 42.81% ± 1.32%. The predicted HRFK growth was 17.06% ± 1.02% per year, holding other factors constant. A 1-standard deviation increase in FARM correlated with a 14.68-% point decrease in predicted test score ($p = 0.02$). A 1-standard deviation increase in SAP was associated with an 11.90%-point increase in HRFK score. Males had a significantly lower growth rate than females during the middle school years (0.78%/year, $p = 0.02$).

Conclusion: The result showed that both individual- and school-level variables such as gender, FARM, and SAP influenced HRFK growth. Educators should heed gender differences in growth curves and recognize the correlates of school-level variables.

Keywords: Academic achievement; Fitness concept; Learning rate; Physical education; Socioeconomic status (SES)

1. Introduction

Health-related fitness knowledge (HRFK) encompasses the concepts and skills necessary to improve and maintain health-enhancing levels of physical fitness and physical activity (PA).[1,2] HRFK is an essential element for health and physical education (PE) to nurture physically literate individuals capable of independent PA and fitness planning,[1,2] and it is an important factor for health educators to cultivate health literacy.[3,4] While HRFK is recognized as an area in need of improvement among students to promote health-related behaviors,[5] the extant literature examining HRFK in PE and health education contexts is fragmented and sparse[6] compared to the comprehensive research efforts on physical fitness.[7,8]

Studies have shown that HRFK is potentially linked to exercise intent and PA,[9,10] and concept-based PE promotes voluntary PA and a physically active lifestyle.[11,12] Research examining the HRFK of adolescents has demonstrated that they tend to lack essential HRFK and that they may have misconceptions about fitness (e.g., equating being "skinny" to being fit).[13,14] The lack of HRFK among adolescents is believed to be one of the factors that contribute to physical inactivity and the continued obesity epidemic among the youth population.[14,15] Theoretically, improving HRFK may lead to fitness independence and improvements in healthy living behaviors of adolescents.[16] To this end, a recent systematic review of literature focusing on school-based PA interventions and their effects on students' HRFK found that most published studies (79.4%) revealed significant positive intervention effects; however, many were of either moderate (70.6%) or low (26.5%) methodologic quality.[5] Interestingly, most studies included in this review focused on classroom-based interventions and just a few included interventions that, to some degree, took

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* Corresponding author.
E-mail address: x2zhu@odu.edu (X. Zhu).

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place in traditional PE settings.[5] Additionally, other studies in PE have reported the effectiveness of using well-focused curricular approaches to promoting students' HRFK.[17−19] While the results vary, they are generally significantly positive. Despite their varying effects, these findings suggest that well-focused health and PE could increase HRFK,[17−19] which could in turn positively influence PA behaviors.

Health and PE in schools are positioned to play a key role in nurturing students with knowledge and behaviors associated with living a healthy lifestyle.[20,21] Scholars recently have contended that physical and cognitive experiences in PE should extend beyond observable changes in movement (e.g., engagement in PA) and lead to knowledge gain that can be applied to other times and contexts.[22] As such, promoting HRFK through learning tasks and physical movement is an essential goal in PE. Despite the encouraging results from earlier studies,[5,17,18] the extant literature examining HRFK promotion in PE contexts are mostly limited to relatively short durations, typically lasting from 4 to 16 weeks.[17] While the national norms for physical fitness development across different age groups has been available for decades,[7,23] there is a lack of reports on HRFK growth across multiple school years due to various factors, such as fragmented research agendas and different curricular and/or testing approaches.[8]

In addition to instructional and curriculum-related variables,[24] demographic and broad context factors such as socioeconomic variables have been shown to impact student achievement.[25] Examining individual- and school-level correlates with student achievement and behaviors has been well recognized in education and public health research.[26,27] However, most of the existing studies on HRFK have not examined the impacts of broad context factors, such as socioeconomic and academic achievement variables, at the school level due to its nested structure and/or lack of school-level data.[22,28] Thus, the extent to which these sociodemographic variables impact student HRFK growth remains unknown. Therefore, in the present study we used both individual- and school-level data to (a) evaluate students' HRFK growth through their middle school years while they learned a fitness-focused curriculum, and (b) examine the correlates of individual- and school-level variables of HRFK growth under one curriculum condition: the *Five for Life − Intermediate* curriculum (Focused Fitness, 2015; Spokane Valley, WA, USA). We hypothesized that students' HRFK will increase as they advance through grade levels in middle school years, and that individual- such as gender and school-level variables will be related to HRFK growth. *Five for Life* is a fitness-centered PE curriculum that has been implemented in multiple states in the United States. The intermediate curriculum is designed specifically for middle-school-aged youth and focuses on promoting the participants' understanding of the relationship between fitness and long-term health. Understanding students' knowledge growth in one curriculum condition (i.e., *Five for Life − Intermediate*) and its impacting factors provides valuable reference points for further empirical longitudinal investigations. Additionally, studying the student-level factor such as gender will help further the understanding of the knowledge learning inconsistency among existing studies.[14,28]

2. Methods

2.1. Study design

A longitudinal observational design was used in this study, in which middle school students were tested annually over a period of 3 years while they learned the *Five for Life − Intermediate* curriculum. A convenience sampling approach was used to recruit participants. This study used an existing dataset that was collected by 6 school districts while they implemented the curriculum. Because a retrospective dataset from a large number of schools was used, the researchers had no control over the degree of implementation at each school level since it was assumed that varying degrees of implementation took place among the schools.

Five for Life − Intermediate was designed to teach essential fitness and health-related content through PAs. The curriculum was developed by a group of experienced health and physical educators, with a panel of experts providing the content consultancies to ensure scientific accuracy. Each PA allowed students to apply and evaluate their own health-related knowledge, in that learning each fitness concept was the central focus of the curriculum. Activities designed for middle school students required a higher level of understanding and application of content. The curriculum also allowed for periodic self-evaluations that enabled students to observe their progress in maintaining or improving different components of fitness.[29] The curriculum emphasized the knowledge and skills needed for personal planning and behavioral management, and students were required to evaluate their own behaviors and design a plan of action to improve or maintain their health and fitness.

2.2. Participants

Participants included 12,044 middle school students (48.9% female) from 47 middle schools in 6 districts in an eastern state of the United States. The participants were on average 12.96 ± 0.98 years old (range: 10−16) and were enrolled at the 6th- through 8th-grade levels. At the school level, the participants were 11.67% Asian/Asian American, 18.59% black/African American, 16.83% Latino/Hispanic, 47.63% white/Caucasian, and 5.28% other. The participants were socioeconomically diverse, with the free and reduced meals (FARM) rate ranging from 4.21% to 81.56% at the school level. The study protocols have been reviewed and approved by the Darden College of Education and Professional Studies Human Subjects Review Committee (#872750-1), and the participants and their parents/guardians provided the informed consents in their respective school districts which collected the tests data.

2.3. Variables and instruments

This study included variables at both participant/person and school/institution levels. Participant-level variables included gender, grade, and HRFK test scores. Participant HRFK was assessed by an HRFK test that was designed specifically for the *Five for Life − Intermediate* curriculum. To indicate student performance, we calculated the percentage correct score using the number of correct responses divided by the total number of items. The questions were content validated through a panel of experienced health and PE specialists and curriculum experts. While there were different versions of the knowledge tests used in different grade levels and schools, there were 11 common items deployed in all versions of the tests, making it possible to explore knowledge growth across school years. These 11 items tested the essential concepts in the curriculum and had a split half reliability of 0.76. An example question is shown below, with the correct answer marked by a star.

Doing more than 12 biceps curls in 1 set will help improve ()

a cardiorespiratory endurance
b flexibility
c muscular endurance*
d muscular strength

The school-level variables included (a) percentage of students receiving FARM, (b) student-faculty ratio for PE (S/F-PE), and (c) school academic performance (SAP). FARM and S/F-PE were collected from school district websites and report data from the state department of education. S/F-PE was calculated by dividing school enrollment by the number of full-time PE teachers. The SAP data were collected from the state department of education website. For each school, we collected the school-level passing rate (%) for reading, mathematics, science, and social science for the past 3 years. Passing rates were highly correlated at the school level, with the correlation coefficient r ranging from 0.85 to 0.94 among the 4 tested areas. We computed the aggregated average passing rate for each school to indicate SAP. Specifically, for each school, SAP was computed as $\sum_{1}^{i}\sum_{1}^{j} Subject_{ij}/ij$, where the pass rate of subject i ($i = 4$) passing rate for jth year ($j = 3$) for the past 3 years was summed and then averaged.

2.4. Procedure

The school-level data were collected through the school district websites and school reports from the state department of education website. The de-identified student-level data were collected using an online platform, Welnet (Focused Fitness LLC), where the knowledge test was deployed. The participants completed the tests online from 2012 to 2016 as they progressed from 6th- through 8th-grade levels. Some schools started in 2012, and others started later. Thus, participants from certain schools had 3 data points, where others had 2, with 1 test per year. Test scores with at least 2 data points in 2 years were retained for the purpose of this study. As the participants were taking the knowledge test, their age, grade level, school, and date of the test were also recorded. In cases where a school used the test in a pre-test and post-test format, only the post-tests were retained for the specific grade level.

2.5. Data analysis

Because participant-level and school-level data are encompassed in the study, we used hierarchical linear modeling (HLM) for data analysis.[30] Since HRFK was measured at the student level multiple times, a 3-level HLM was considered proper and was used to model student knowledge change across the years in relation to individual- and school-level factors.[30] School-level variables were grand mean centered using z scores. Model and statistical assumptions were based on recommended practices, and model specifications were screened prior to model testing.[30] Specifically, we checked Mahalanobis distance and P-P plot for normality, scatterplot for linearity, and residual Q-Q plot for homoscedasticity. Then, we began with fitting a full unconditional model, which provided information for adding further parameters for Level 1, Level 2, and Level 3. Full information maximum likelihood estimation was used to compute the variance covariance components. Eventually, Level 1, with an individual fitness knowledge growth model at time t of participant i in school j, was specified:

$$Y_{tij} = \pi_{0ij} + \pi_{1ij}(\text{Year})_{tij} + e_{tij} \tag{1}$$

where Y_{tij} was the health-related fitness test score at time t for participant i in school j; $(\text{Year})_{tij}$ was computed as grade-6, centered on 6th grade. π_{0ij} was the initial HRFK test score for child i in school j at grade 6. π_{1ij} was the first-order growth rate for participant ij during the academic year; and e_{tij} was the Level 1 random error. At Level 2, we specified the model:

$$\pi_{0ij} = \beta_{00j} + \beta_{01j}(\text{Gender})_{ij} + r_{0ij} \tag{2a}$$

$$\pi_{1ij} = \beta_{10j} + \beta_{11j}(\text{Gender})_{ij} \tag{2b}$$

In these equations, β_{00j} represented the mean health-related fitness test score within school j; β_{10i} was the mean academic year growth rate within school j for females; and $(\text{Gender})_{ij}$ was coded 0 for females, and 1 for males. β_{01j} and β_{11j} were gender difference in fitness knowledge test score, and first-order growth rate in school j, respectively. The Level 2 random error included r_{0ij}. The level 3 model was presented below:

$$\beta_{00j} = \gamma_{000} + \gamma_{001}(\text{FARM})_j + \gamma_{002}(\text{S/F}-\text{PE})_j + \gamma_{003}(\text{SAP})_j + \text{u}_{00j} \tag{3a}$$

$$\beta_{01j} = \gamma_{010} \tag{3b}$$

$$\beta_{10j} = \gamma_{100} + \gamma_{101}(\text{FARM})_j + \gamma_{102}(\text{S/F}-\text{PE})_j + \gamma_{103}(\text{SAP})_j \tag{3c}$$

$$\beta_{11j} = \gamma_{110} \tag{3d}$$

In these equations, where γ_{000}, γ_{100} represented the average school test score and average school growth rate of HRFK holding FARM, S/F-PE, and SAP constant. The Level 3 random error was u_{00j}. We hypothesized in the model that school-level variables FARM, S/F-PE, and SAP predict HRFK test score, and that they are associated with gender differences in growth

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Table 1
Student-level frequency and school-level descriptive results (n = 12,044).

Student level	Frequency	School level	M ± SD	Minimum	Maximum
Female/male	48.9%/51.1%	FARM (%)[a]	30.34 ± 20.84	4.21	81.56
Grade 6	36.9%	S/F-PE	204.55 ± 55.55	131.14	395.75
Grade 7	37.3%	SAP (%)[b]	84.74 ± 10.26	58.25	96.50
Grade 8	25.8%	Test score (%)	61.57 ± 12.46	25.00	84.10

Note: [a] Percent of students at school; [b] Percent of students passing state test.
Abbreviations: FARM = free and reduced meals; M = mean; SD = standard deviation; SAP = school academic performance; S/F-PE = student-faculty ratio for physical education.

rates of the test scores at individual level. We conducted the data analyses using HLM Version 6.08 (Scientific Software International; Skokie, IL, USA), and kept $\alpha = 0.05$.

3. Results

As shown in Table 1, the average S/F-PE was 204.55 ± 55.55:1. The overall mean for the HRFK percentage score was 61.57% ± 12.46% across 3 grade levels. The composite average for SAP was 84.74% ± 10.26% for passing the state test. The full unconditional model showed that the intra-class correlation coefficient, $\rho = 0.16$, suggested that a significant portion of the variance in student HRFK could be explained at the school level. Through the HLM testing process, the final model (deviance = 214,354.13, parameter (#) = 17), as displayed in Table 2, showed a significantly better fit than the full unconditional model (deviance = 220,471.01, parameter = 4), $\Delta\chi^2 = 6116.88$, $\Delta df = 13$, $p < 0.001$. Because adding a quadratic function of the year did not improve the model, the linear model was retained as the final result.

The final model (Table 2) showed that the predicted average HRFK score at 6th grade for females was 42.81% ± 1.32%, holding other factors constant. For males, the predicted score for 6th grade was 0.73 points higher (although it was not statistically significant) than for females ($p = 0.11$). FARM was a significant negative predictor for student scores; one standard deviation change in FARM was associated with a 14.68%-point variation in predicted test score ($p = 0.02$). S/F-PE was not a significant predictor for the student HRFK score. SAP was positively associated with student test scores, with borderline statistical significance ($p = 0.05$). A 1-standard deviation change in SAP was associated with an 11.90%-point change in predicted HRFK score.

As shown in Table 2, the predicted student HRFK growth was 17.06% ± 1.02% each year, holding other factors constant. FARM, SAP, and S/F-PE were not significantly associated with the HRFK growth rate ($p \geq 0.09$). Gender was significantly associated with student HRFK growth rate ($p = 0.02$). Specifically, males had a significantly lower growth rate than females during the middle school years. As illustrated in Fig. 1, male students scored lower than females by 8th grade because of this growth rate difference, even though male students started with a slightly higher HRFK score than females in 6th grade, holding other factors constant.

In summary, the final 3-level growth model yielded a global pseudo-$R^2 = 0.39$, explaining about 39.71% of variance in student HRFK scores. As shown in Table 3, the model has explained the variance well in student individual knowledge growth rate ($p = 0.50$), but there was still a significant amount of variance to be explained in school-level knowledge scores, growth, and individual scores ($p < 0.001$). Middle school students using the *Five for Life − Intermediate* curriculum were able to significantly increase their HRFK from 6th to 8th grades, although males reported significantly lower knowledge growth rate than females.

4. Discussion

The purpose of this study was 2-fold: (1) to examine HRFK growth in the middle school years when students were learning the *Five for Life − Intermediate* curriculum and (2) to examine the individual- and school-level correlates of HRFK growth. The findings in this study contribute to the existing literature by revealing HRFK growth rate and patterns under a specific curriculum condition. The study also presents empirical evidence related to the impacts of sociodemographic factors. The results have important implications for health and PE practices as well as for individuals making curricular decisions for schools districts.

Table 2
Predicting middle school student health-related fitness knowledge growth.

Fixed Effect	Coefficient (95%CI)	SE	t ratio	df	p
Model for test score, π_{0ij}					
Predicting, β_{00j}					
Intercept, γ_{000}	42.81* (40.73 to 44.89)	2.08	20.59	43	0.00
FARM, γ_{001}	−14.68* (−20.95 to −8.41)	6.27	−2.34	43	0.02
S/F-PE, γ_{002}	4.04 (1.9 to 6.18)	2.14	1.88	43	0.07
SAP, γ_{003}	11.90 (5.98 to 17.82)	5.92	−2.01	43	0.05
Predicting β_{01j}					
Intercept gender, γ_{010}	0.73 (0.28 to 1.18)	0.45	1.60	12,042	0.11
Model for growth rate, π_{1ij}					
Predicting, β_{10j}					
Intercept, γ_{100}	17.06* (16.04 to 18.08)	1.02	16.69	43	0.00
FARM, γ_{101}	4.10 (1.01 to 7.19)	3.09	1.32	43	0.19
S/F-PE, γ_{102}	−1.16 (−2.18 to −0.14)	1.02	−1.14	43	0.26
SAP, γ_{103}	5.06 (2.15 to 7.97)	2.91	1.74	43	0.09
Predicting, β_{11j}					
Intercept gender, γ_{110}	−0.78* (−1.12 to −0.44)	0.34	−2.28	12,042	0.02

Note: * $p < 0.05$.
Abbreviations: CI = confidence interval; FARM = free and reduced meal (% at school); SAP = school academic performance (% of student passing state test); SE = standard error; S/F-PE = student faculty ratio for physical education.

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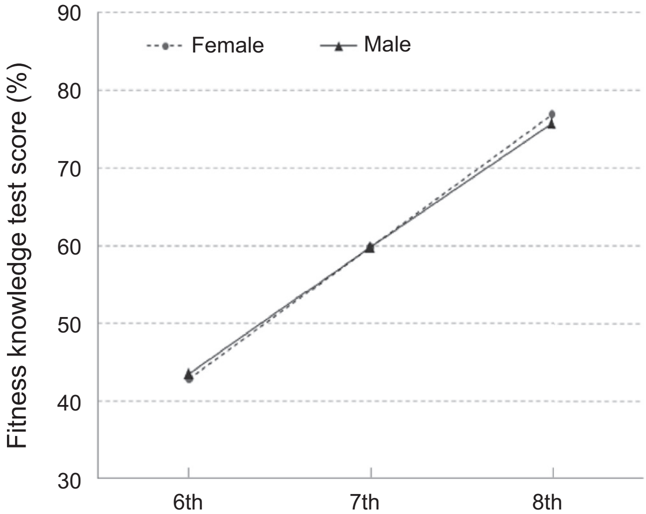

Fig. 1. Predicted average health-related fitness knowledge growth in the middle school years.

The HRFK growth in the middle school years reported in this study extends the existing literature in that it documents that a well-focused curriculum, *Five for Life – Intermediate*, was able to increase student HRFK.[17–19] This finding remedies to some degree the gap in our understanding of HRFK growth due to the lack of longitudinal studies in health and PE.[8] Compared to the annual HRFK growth rate in elementary school,[18] the HRFK growth rate in this study was lower, but was comparable to that found in a previous middle school study.[17] However, it should be noted that the curricular conditions differed between the previous study and the present study. Additionally, our data were consistent with previous reports that students had inadequate HRFK, since the first-year (6th-grade) scores in our study were low.[5,13,14] It is encouraging that by using the *Five for Life – Intermediate* curriculum, HRFK steadily improved over the years. More important, the longitudinal data in our study, while limited to 1 curriculum condition, suggested that students' HRFK growth in the middle school years was linear,[28] not curvilinear as with vocabulary growth.[31] As shown in Fig. 1, females displayed a higher HRFK growth rate than males, suggesting that males may need extra support under the *Five for Life – Intermediate* curriculum condition if they are to equal the HRFK growth rate achieved by females.

Table 3
Variance decomposition for a 3-level analysis of health-related fitness knowledge growth.

Random Effect	σ^2Component	$\chi 2$	*df*	*p*
Level 1 variance				
Temporal variation, e_{tij}	285.59			
Level 2 (within schools)				
Individual initial status, r_{0ij}	138.16	14,387.61	11,555	0.00
Individual growth rate, r_{01j}	6.41	11,554.44	11,555	0.50
Level 3 (between schools)				
School mean status, u_{00j}	148.94	3541.14	41	0.00
School growth rate, u_{10j}	31.84	919.46	41	0.00

Consistent with the findings from studies involving other academic areas,[25] the results from our study provide empirical evidence that school-level FARM is negatively associated with HRFK, and that SAP is positively related to students' HRFK growth. In other words, HRFK growth in health and PE classes is likely to correlate with school-level SAP as measured by school-level passing rates in statewide assessments. These findings suggest that research in HRFK promotion should report on these school-level variables and consider their impact. While it was known that lower S/Fs are favorable for student learning,[32] S/F-PE was not significantly associated with HRFK growth in our study. We would note that the extremely high S/F ($M = 204.55$) for health and PE was likely to be a culprit in diminishing S/F-PE effects. Researchers should further explore the effects of S/F-PE on student learning in health and PE.

HRFK has been recognized as an important contributor in promoting health-related behaviors (e.g., PA)[5] and it goes hand in hand with fitness promotion in schools.[4,7] For example, standard 3 of the current national PE standards[1] focuses on ensuring that students demonstrate the knowledge and skills to achieve and maintain a health-enhancing level of PA and fitness. Therefore, it is essential for schools to offer and implement curricula that can enhance student HRFK. This study provided evidence of HRFK growth under the *Five for Life – Intermediate* curriculum during the middle school years. While some stakeholders have suggested a balanced approach to HRFK and PA,[33] a well-crafted curriculum may not necessarily risk the loss of PA for HRFK growth in PE.[34] Our results suggest that the *Five for Life – Intermediate* curriculum is promising for use with middle school students in HRKF promoting HRFK in schools and that school personnel (health and PE teachers) and administrators should consider its use when deciding to implement a fitness-centered curriculum.

Health and PE programs should heed gender differences in HRFK growth curves and recognize the importance of correlates of school-level variables in educating the whole child. The results of this study also demonstrate that school-level variables, such as FARM and SAP, can influence HRFK scores. Furthermore, extremely high S/F-PE in this study may impede any benefits that schools may see from having a reasonable S/F. Based on our results, and considering the advocacy for "whole-school, whole-student" approaches,[21] researchers and schools must collaborate to take a closer look at how school-level variables impact students' HRFK growth in the middle school years.

One notable limitation of the study was that it lacked a comparison group, thereby limiting its ability to generalize the comparative effectiveness of the different curricula in HRFK growth or to control for the natural growth rate as a result of student cognitive development. Our findings resulted from the use of 1 specific curriculum condition; thus, they may or may not transfer other contexts. Similarly, the test items we used were developed and validated for the *Five for Life – Intermediate* curriculum only, which may also limit the generalizability of the findings. Nevertheless, to our knowledge this is the first study reporting on HRFK growth across multiple years and on both individual- and school-level correlates for HRFK growth in middle school students.

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5. Conclusion

The results of our study show that students involved in the *Five for Life − Intermediate* curriculum achieved, on average, a 17.06% HRFK growth rate each year compared to the previous year, which represents a unique contribution in a specific curriculum context. Females tended to have a slightly higher HRFK growth rate than males during their middle school years. More research on and support for male students in regard to their HRFK growth rates is needed. The school-level socioeconomic indicator FARM was negatively associated with HRFK performance, and school-level SAP was positively associated with HRFK, with borderline significance. Future research on HRFK in school-based health and PE settings should consider these variables and report on them.

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Authors' contributions

XZ was responsible for acquiring the data, conducted the statistical analyses, and drafted the initial manuscript; JAH was responsible for acquiring the data, drafted the initial manuscript; HS participated in the study design and manuscript revision processes. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

The authors declare that they have no competing interests.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jshs.2019.04.005.

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