Physical Activity, Inactivity, and Nutrition Behavior Among Children: Investigating Compensation and Transfer Effects

Judith Väth[1], Katie Amato[2] and Claudio R. Nigg[2]
[1]*Institute for Sport and Sport Sciences, University of Karlsruhe, Karlsruhe*
[2]*Department of Public Health Sciences, University of Hawai'i at Mānoa, Honolulu, HI*
[1]*Germany*
[2]*USA*

1. Introduction

The increasing prevalence of overweight children is an important public health problem in the United States. Nearly 1/3 of children are considered to be at risk for being overweight and currently more than 9 million children over 6 years of age are considered obese (Ogden et al. 2002; Koplan et al. 2005). Obesity and being overweight is a risk factor for several diseases: type 2 diabetes, cardiovascular disease, hypertension, osteoporosis, and certain types of cancer (Eaton et al. 2006).

Both physical activity (PA) and nutrition behaviors have been shown to be an important and effective method to reduce weight. Physical activity expends energy and can lead to a reduction in weight loss. A meta-analysis showed that there is a small to moderate relationship between body fat and activity in children (Rowlands, Ingledew and Eston 2000). But to reduce adiposity in children and adolescents of normal weight an intense level of PA for a longer duration is needed (Barbeau and Litaker 2003; Eliakim et al. 2000). Time spent in vigorous and hard activity correlated significantly with percentage of body fat but not with BMI in 5-10.5 year-olds (Abbott and Davies 2004). Physical activity not only positively influences physiological factors, but also has a positive effect on psychological aspects. Regular PA can increase the ability to cope with stress and lead to an improved health perception and quality of life (Röthlosberger, Calmonte and Seiler 1997). Strong et al. (2005) emphasized many other beneficial effects of PA, such as better cardiovascular health and self-esteem.

Most research examining physical inactivity focuses on television (TV) viewing. Some cross-sectional studies found positive associations between TV viewing and obesity. An analysis of the CDC 1999 Youth Risk Behavior Survey demonstrated a significant association between overweight and viewing TV more than 2 hours per day (Lowry et al. 2002). Also, eating meals in front of the TV may influence energy intake because it is associated with lower fruit, vegetable, and juice intake and greater intake of salty snacks, pizza, soft drinks, and red meat (Proctor 2003; Coon et al. 2001).

Some clinical evidence shows that receiving advice to increase fruit and vegetable consumption is an effective strategy for weight management as fruits and vegetables have a low energy density, are high in fiber, and may cause satiety. In addition, consumption of fruits and vegetables could also displace consumption of less healthy and higher energy-dense foods (Sherry 2005). Children and adolescents in the US have not consumed the recommended 5 servings of fruits and vegetables per day (Cavadini, Siega-Rizz and Popkin 1996). Studies report that only 18% of girls and 14% of boys consume the recommended number of servings of fruits and vegetables (American Dietetic Association 2004; Enns, Mickle and Goldmann 2003).

Relationships between PA, inactivity, and nutrition behavior are consistently shown in studies on elementary school children (Sallis, Prochaska and Taylor 2000; Driskell et al. 2008; Pearson and Biddle 2011). For example, in a comprehensive review of PA correlates among children Driskell et al. (2008) found that healthy diet, intention to be active, and PA preferences (among others) cluster with PA. Traditionally, PA and nutrition interventions have focused on influencing single behaviors. However, recent research suggests that multiple behavior change interventions may have a greater impact than single behavior change interventions (Nigg, Allegrante and Ory 2002; Emmons et al. 1994). Because these behaviors are associated in individuals; combined PA, inactivity, and nutrition interventions hold promise for effectively influencing multiple outcomes. In a PA and healthy eating intervention evaluation on adults, a multiple behavior intervention was 3 times as successful as a single behavior intervention (Johnson et al. 2008). In another study on children, a combined nutrition and PA group scored significantly better than a control group on measures of nutrition knowledge. Results of single- and multiple behavior change interventions imply that future investigation of how changes in PA, inactivity, and nutrition may impact each other is warranted (Warren et al. 2003).

Physical activity, inactivity, and nutrition behaviors may act as gateway behaviors. Gateway behaviors are those which when changed lead to a positive change in another health behavior (Nigg et al. 2009). Depending on the interaction of the behaviors, change in more than one behavior may be due to transfer or compensation effects. Borrowed from learning and teaching research (Barnett and Ceci 2002), transfer effects describe the translation of knowledge and confidence in one health behavior to another. Research on transfer effects is inconclusive: some studies report null results (Ussher, Taylor and Faulkner 2008; Wilcox et al. 2000), while others provide support (Nigg et al. 2009; Fleig et al. 2011). Transfer effects may depend on the 1) co-occurrence of behaviors 2) similarity of health behavior domains (Flay and Petraitis 1994), and 3) individual ability to transfer skills to another domain (Perkins and Saloman 1994).

Because PA, inactivity, and nutrition are associated and naturally co-occur, transfer effects may explain the success of behavior change interventions. To date, transfer effects in these domains have not yet been investigated in children. Research on single behavior interventions measuring other behaviors has found support for transfer effects between PA and nutrition in adults. One study found that self-efficacy in exercise served as a gateway to healthy diet (Tucker and Reicks 2002). Additionally, a recent exercise intervention found PA transfer effects on fruit and vegetable intake (Fleig et al. 2011). Combined PA and nutrition interventions evaluating transfer effects are few. One intervention comparing single versus multiple behavior interventions that targeted PA and fat intake found that success at improving both behaviors was not associated with intervention condition (Vandelanotte et al. 2008). Results suggest that participants who successfully changed both behaviors in the single behavior change intervention experienced transfer effects.

In contrast to transfer effects, the opposite interaction effect may occur where individuals may compensate for their risk behavior by performing another health behavior (see Compensatory Health Belief Model, Knauper et al. 2004). For example, it has been shown that smokers are more physically active in order to compensate for their unhealthy lifestyle (Xu 2002). Less literature is available on compensation effects of PA, inactivity, and nutrition. One study exploring the effects of a PA intervention on adult's nutrition found that PA was not a gateway behavior for fruit and vegetable consumption. Instead, they found that increases in PA activity were associated with increases in fat intake (Dutton et al. 2008) suggesting that participants may have compensated for increased fat intake with increased PA. Both transfer and compensation effects of PA, inactivity, and nutrition behavior may have important intervention implications, but they have not yet been explored in children. Therefore, the purpose of the current study is to compare PA, inactivity, and nutrition behavior, their influence on each other in children, and to determine if there are compensation or transfer effects.

2. Methods

Twenty-one schools in the state of Hawaii (the islands of Oahu, Hawaii, and Maui) participating in Fun 5 were randomly selected and stratified by afterschool care provider, year joined, and county. Fun 5 is a nutrition and PA program aimed at reducing obesity through increasing fruit and vegetable consumption and PA (Battista et al. 2005). Parental consent and student surveys containing PA, inactivity, and nutrition behavior questions were sent to the site coordinators with instructions for distribution, administration, and return of completed materials. One site did not return any surveys and 7 sites did not get parental permission. A significant portion of sites' student surveys (N= 250) were obtained without consent and destroyed. In the final analysis, only students from 13 sites were evaluated. There were two measurement points: one at the beginning of the school year (Fall 2005 – baseline T1); and the other at the end of the school year (Spring 2006 – follow-up T2). The University of Hawaii Committee on Human Subjects approved this research.

2.1 Participants

Participants were enrolled in Hawaii's A-Plus public elementary after-school program (A+). A+ is a state mandated after-school program for children in public elementary schools that begins immediately after the end of the school day until the last child is picked-up (2pm~5:30pm). The program includes snack time, homework time, PA, and enrichment activities such as arts and crafts.

At T1, 188 student surveys from 13 sites were available for analysis (53.2% female; grade 4= 39%; grade 5= 34%; and grade 6= 27%). At T2, 137 students (56.7% female; grade 4= 37%; grade 5= 37%; and grade 6= 26%) completed the survey from the same 13 sites. For the analysis, only children who took part on both measurement points are included. Table 1 shows the sample of those participants that completed T2 and those that did not complete T2.

	Completed (N= 137)		Not completed (N= 51)		t-test	
Variable	mean	Std.	mean	Std.	df	sig.
Strenuous PA (min/wk)	202.28	135.86	213.14	137.18	185	.628
Moderate PA (min/wk)	147.45	125.47	152.24	137.72	184	.823
Mild PA (min/wk)	119.48	140.75	136.67	141.08	181	.469
Inactivity (hrs/day)	4.47	3.252	3.88	3.090	186	.268
Fruit (serv/day)	4.69	2.950	4.32	2.622	180	.438
Vegetable (serv/day)	3.77	2.825	3.82	2.561	179	.915

Note: PA – physical activity; min – minutes; wk – week; hrs – hours; serv – servings
Std. – Standard deviation; df – difference; sig – significance; N – numbers.

Table 1. Mean, standard deviation and significance of PA, inactivity, and nutrition variables at T1 (completed or not completed T2)

2.2 Measures

The student survey included measures on demographics (grade and gender), PA, inactivity, and fruit and vegetable consumption. An adaptation of Godin & Shephard's Leisure-Time Physical Activity Questionnaire (Godin and Shepard 1985) indicates how many days during an average week people are engaged in strenuous, moderate, and mild PA during their free time. Strenuous PA is defined as "heart beats rapidly, sweating" examples are: running, jogging, soccer, squash, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling, vigorous aerobic dance classes, and/or heavy weight training. Moderate PA is defined as "not exhausting, light sweating" examples are: fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, popular, folk and / or hula dancing. Mild PA is defined as "minimal effort, no sweating, e.g. easy walking, yoga, archery, fishing, bowling, lawn bowling, shuffleboard, horseshoes, and/ or golf. For a sample of adults (Godin and Shepard 1985) aged 18-65 years, two-week test-retest reliabilities of .94, .46, and .48 were reported for strenuous, moderate, and mild PA respectively. Strenuous PA was significantly associated with maximum oxygen intake (VO2max; r = .38) and percentage of body fat (r = .21). The instrument was found to be significantly related to caloric accelerometer readings (r = .32), metabolic equivalents (METs; r = .36), treadmill PA time (r = .57), percentage of body fat (r = -.43), VO2max (r = .56), and the stages of PA across populations (Jacobs et al. 1993; Lee et al. 2001; Schumann et al. 2002). A second set of questions reflects the minutes (in 10 min increments) that participants spent in each activity level each day. This allows a calculation of min/week of PA for each intensity level.

For sedentary behavior one question addressed how many hours the student watched TV or played video games on an average day (Buckworth and Nigg 2004). Validity of this item has shown a small negative correlation in PA with children (Nigg 2005).

Participants reported how many servings of fruits and how many servings of vegetables they ate each day. A serving was described as: ½ cup of cooked vegetables = size of 2 ping-pong balls; 1 cup of salad = size of 1 baseball; 1 piece of fruit = size of 1 baseball; or ¾ cup of 100% fruit juice = 6 ounces. The single items addressing the average number of fruits and the average number of vegetables eaten each day have documented validity and reliability in adolescents (Prochaska 2000).

2.3 Analysis

Data analysis was conducted via SPSS 14.0 (2005, SPSS Worldwide Headquarters, Chicago, IL). Three variables represent PA level in min/week (strenuous, moderate, mild), one variable measures the inactivity (TV watching or videogame playing), and two variables address healthy nutrition behavior (fruit and vegetable consumption). For the measurement of strength and direction of cross-sectional relationships Pearson Correlations were conducted. Cohen's guidelines (1988) for interpretation of the correlation coefficient were used: small ranging from │.10│ - │.29│; medium ranging from │.30│ - │.49│; and large ranging from │.50│ – │1.0│. A linear regression was conducted to assess the longitudinal relationship between a dependent variable, independent variables, and a random term. Independent variables were all the behaviors at T1. For example, strenuous PA, moderate PA, mild PA, inactivity, fruit and vegetables at T1 were used to predict one dependent variable at T2 (e.g., strenuous PA).

3. Results

A t-test was conducted to compare those who completed T2 with those who did not complete T2. Means and standard deviations are represented in Table 1 and show for all six variables that there is no significant difference between both groups ($p > .05$). Only the 137 participants who completed T1 and T2 were included in the analysis. Cross-sectional analysis with all the participants at T1 did not alter any conclusions (results not shown). Table 2 shows the mean and standard deviation of all variables across time. There were no significant differences between T1 and T2 ($p > .05$).

	T1 (Fall 2005)		T2 (Spring 2006)		t-test	
Variable	mean	std.	mean	Std.	df	Sig.
Strenuous PA (min/wk)	202.3	135.9	214.2	134.8	133	.430
Moderate PA (min/wk)	147.4	125.5	147.1	127.0	135	.971
Mild PA (min/wk)	119.5	140.7	126.1	142.0	132	.530
Inactivity (hrs/day)	4.47	3.252	4.26	3.094	135	.606
Fruit (serv/day)	4.69	2.950	4.18	2.784	125	.111
Vegetable (serv/day)	3.77	2.825	3.77	2.577	124	.842

Note: PA – physical activity; min – minutes; wk – week; hrs – hours; serv – servings Std. – Standard deviation; df – difference; sig – significance

Table 2. Mean, standard deviation and significance of PA, inactivity, and nutrition variables

The correlations between the variables of PA, inactivity, and nutrition behavior of T1 are represented in Table 3 and Table 4 shows the same correlations for T2. Regarding T1: there is a small correlation between strenuous PA and fruit consumption (r= .256**), between mild

PA and inactivity (r= .181*), between mild PA and fruit consumption (r= .229*) and also between mild PA and vegetable consumption (r= .248*). A medium correlation could be found between strenuous and mild PA (r= .366**), between moderate and mild PA (r= .419**), between moderate PA and fruit consumption (r= .370**), between vegetable consumption and strenuous PA (r= .337**) and moderate PA (r= .379**). Large relationships between strenuous and moderate PA (r= .558**) and between fruit and vegetable consumption (r= .624**) were found.

Pearson's correlation	Strenuous PA (min/wk T1)	Moderate PA (min/wk T1)	Mild PA (min/wk T1)	Inactivity (hrs/day T1)	Fruit (serv/day T1)	Vegetable (serv/day T1)
Strenuous PA (min/wk T1)		.558**	.366**	-.003	.256**	.337**
Moderate PA (min/wk T1)			.419**	.084	.370**	.379**
Mild PA (min/wk T1)				.181*	.229*	.248*
Inactivity (hrs/day T1)					.069	.008
Fruit (serv/day T1)						.624**
Vegetable (serv/day T1)						

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)
Note: PA – physical activity, min – minutes, wk – week, hrs – hours, serv – servings

Table 3. Correlation between PA, inactivity, and nutrition variables of T1

Pearson's Correlation	Strenuous PA (min/wk T2)	Moderate PA (min/wk T2)	Mild PA (min/wk T2)	Inactivity (hrs/day T2)	Fruit (serv/day T2)	Vegetable (serv/day T2)
Strenuous PA (min/wk T2)		.304**	.274**	-.081	.288**	.163
Moderate PA (min/wk T2)	.		.520**	-.044	.020	.006
Mild PA (min/wk T2)				.043	.052	.054
Inactivity (hrs/day T2)					.062	-.129
Fruit (serv/day T2)						.538**
Vegetable (serv/day T2)						

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)
Note: PA – physical activity, min – minutes, wk – week, hrs – hours, serv - servings

Table 4. Correlation between PA, inactivity, and nutrition variables of T2

Regarding T2: there is a small relationship between mild and strenuous PA (r= .274**), between strenuous PA and fruit consumption (r= .288**). A medium correlation is evidenced for strenuous and moderate PA (r= .304**). A large relationship was found between moderate and mild PA (r= .520**) and between fruit and vegetable consumption (r= .538**).

Dependent / Independent	Strenuous PA (min/wk T2) (r^2=.104)	Moderate PA (min/wk T2) (r^2= .174)	Mild PA (min/wk T2) (r^2= .112)	Inactivity (hrs/day T2) (r^2= .156)	Fruit (serv/day T2) (r^2= .263)	Vegetable (serv/day T2) (r^2= .180)
Strenuous PA (min/wk T1)	.186 *.081*	.298 *.002*	-.015 *.894*	.000 *.921*	.000 *.823*	.003 *.179*
Moderate PA (min/wk T1)	.226 *.062*	.017 *.879*	.238 *.062*	-.004 *.108*	-.004 *.107*	-.004 *.100*
Mild PA (min/wk T1)	-.055 *.569*	.168 *.057*	.189 *.070*	.002 *.393*	.001 *.629*	.000 *.953*
Inactivity (hrs/day T1)	-1.035 *.777*	-3.884 *.250*	1.765 *.655*	.312 *.000*	.050 *.483*	.083 *.244*
Fruit (serv/day T1)	3.371 *.505*	2.794 *.543*	1.394 *.794*	.168 *.139*	.611 *.000*	.056 *.576*
Vegetable (serv/day T1)	-4.574 *.403*	-11.346 *.022*	-.976 *.865*	-.182 *.133*	-.235 *.027*	.336 *.002*

Note: PA – physical activity, min – minutes, wk – week, hrs – hours, serv - servings

Table 5. Linear Regression of PA, inactivity, and nutrition variables (unstandardized Coefficient B, *significance*)

The outcomes of the linear regression analyses (see Table 5) show that there is no significant ($p > .05$) relationship of T2 strenuous PA and of T2 mild PA with all the T1 predictors. However, T2 strenuous PA is marginally ($p \leq .10$) significant with T1 strenuous PA and T1 moderate PA. T2 mild PA is also marginally ($p \leq .10$) significant with T1 moderate PA and T1 mild PA. There is a significant ($p \leq .05$) relationship between T2 moderate PA and T1 strenuous PA (unstandardized coefficient B= .298) and marginally with T1 mild PA (unstandardized coefficient B= .168). Also, a significant negative relationship was found between T2 moderate PA and T1 vegetables (unstandardized coefficient B= -11.346). For T2 fruit consumption there is a significant negative relationship with T1 vegetable consumption (unstandardized Coefficient B= -.235). T2 vegetable consumption and inactivity are only significant predictors of themselves at T1.

4. Discussion

The purpose of the current study was to compare PA, inactivity, nutrition behaviors, and their influence on each other in children to determine if there are compensation or transfer effects between the different domains of behavior. According to the Compensatory Health Belief Model, individuals can compensate their risk behavior by performing another health behavior (Knauper et al. 2004).The opposite effect occurs when individuals transfer their knowledge and experiences from one behavior change to another (Barnett and Ceci 2002).

The results of the cross-sectional analyses show that PA behavior relates to itself and it relates to fruit and vegetable consumption. Students that are strenuously active are more likely to be moderately active. This may be because they warm-up with a moderate intensity activity. Students that are mildly active are also moderately active but are less strenuously active. Regarding the relationship between PA and nutrition behavior, the outcomes of T1 show a strong relationship between moderate PA and fruit and vegetable consumption. Also, strenuous PA is related to fruit and vegetable consumption. The results support a transfer effect because very active children are also more likely to eat more fruits and vegetables.

Regarding the relationship between PA and fruit and vegetable consumption of T2, there is only a small correlation between strenuous PA and fruit consumption. This result also points to a transfer effect. The longitudinal results are weaker: they confirm the transfer effect within PA intensities but not for the transfer to fruit and vegetable consumption.

Cross-sectional and longitudinal analysis shows an independence of the inactivity variable both from PA and from the nutrition variables. Similarly, Anderson et al. (1998) and Nigg et al. (2002) did not find any meaningful relationship between TV watching and PA. Olivares et al. found no association between nutritional status and television viewing (Olivares et al. 2004). However, studies have shown that TV viewing may contribute to a decline in fruit and vegetable consumption among adolescents. Boynton-Jarrett et al. (2003) documented that the fruit and vegetable consumption was negatively associated with hours of TV viewing. Their prospective analyses indicated that both baseline television viewing and change in television viewing independently predicted a reduction in fruit and vegetable consumption.

Cross-sectional and longitudinal results of fruit and vegetable consumption show an expected transfer effect within fruits and vegetables as both variables represent eating behaviors. There is also cross-sectional indication of transfer effects between fruit and vegetable consumption and PA; however, this was not confirmed by the longitudinal analysis. There were no predictive relationships with PA or inactivity. As expected, the relationship is weaker over time as people change their behavior. The longitudinal results also show a negative prediction of fruits by vegetables. This negative relationship between the two nutrition variables has statistical reasons and points to a suppression effect. A statistical suppression means that instead of the drop that we would see from the direct effect of the same behavior on the outcome when vegetable variable is introduced, the opposite happens. The testing of suppression should be evidenced on a priori assumptions about the theoretical relation between the variables and the role of the second predictor variable as a suppressor.

4.1 Limitations

There are some limitations that need to be considered when interpreting the outcomes of this study. First, data was collected by self-report only and thus, the outcomes could possibly be influenced by social desirability. Second, the survey only included questions concerning PA of 10 minutes or more of continuous activity. Corbin and Pangrazi (1998) noted that children normally exercise in short bouts of activity rather than being constantly active. Third, the sample size (N= 137) did not allow for subgroup analysis (e.g., gender). With decreasing numbers the chance of random distortion of the results increases (Boes, Haensel and Schott 2000). Lastly, the large amount of students who did not provide data influenced the representativeness. However, as we were interested in variable relationship and not prevalence we do not deem this a serious limitation.

5. Conclusion

In conclusion, there seems to be no compensation effect between PA, inactivity, and nutrition behavior in children. Inactivity does not seem to be related to PA or nutrition. However, there are important transfer effects between different PA intensities and between nutrition behaviors in children. These outcomes support growing evidence that multiple behavior interventions have the potential for a greater impact on public health than single behavior interventions. More research is needed to understand the mechanisms and moderations (e.g., gender) of the influence and relationship between PA, inactivity, and nutrition behavior. Finally, intervention research should investigate how to capitalize and promote the important transfer effects.

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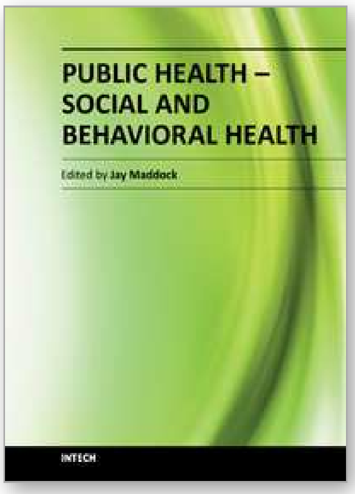

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