EVALUATING THE RELATIONSHIP BETWEEN VIGOROUS PHYSICAL ACTIVITY AND HEALTH RELATED QUALITY OF LIFE AMONG OVERWEIGHT AND OBESE CHILDREN: AN APPLICATION OF DYNAMIC P-TECHNIQUE

BY

KELSEY BRIGGS BORNER

Submitted to the graduate degree program in Clinical Child Psychology and the Graduate Faculty of the University of Kansas in partial fulfillment of the requirements for the degree of Master of Arts.

Chairperson Ric Steele, PhD, ABPP

Ann Davis, PhD, MPH, ABPP

Paula Fite, PhD

Date Defended: December 9, 2013

The Thesis Committee for KELSEY BRIGGS BORNER
certifies that this is the approved version of the following thesis:

EVALUATING THE RELATIONSHIP BETWEEN VIGOROUS PHYSICAL ACTIVITY AND HEALTH RELATED QUALITY OF LIFE AMONG OVERWEIGHT AND OBESE CHILDREN: AN APPLICATION OF DYNAMIC P-TECHNIQUE

____
Chairperson Ric Steele, PhD, ABPP

Date approved: 12/9/2013

ABSTRACT

Pediatric overweight and obesity remain a public health concern, and the majority of children do not meet recommended guidelines for physical activity, increasing their risk for impaired health-related quality of life (HRQOL). Current investigations of the relationship between HRQOL and vigorous physical activity (VPA) are limited by a reliance on correlational and two-time point investigations; as such, intra-individual change processes are unknown in this population. The current study utilized a small-N design to capture the dynamic interactions between daily VPA and HRQOL among four adolescents seeking outpatient treatment for pediatric overweight/obesity. Participant physical activity levels were assessed by accelerometer (ActiGraph model GT3X), and HRQOL ratings were collected via iPod Touch. Intra-individual variability was captured utilizing Dynamic P-Technique, a structural equation modeling technique applied at the individual level. Confirmatory Factor Analyses were completed for each participant. Correlational and dynamic relations between daily HRQOL and VPA were assessed with tests of within-lag covariance and cross-lagged relationships; changes in individual constructs over time were assessed with tests of auto-regressive relationships. All four participants evidenced tremendous variability in HRQOL measurement across duration of the intervention. Only two factors of HRQOL held factor structure across time (i.e., Positive Social Attributes and Emotional HRQOL). Several limitations of HRQOL are discussed to explain the relatively poor performance of HRQOL. Significant auto-regressive relationships for HRQOL were found for two participants, and significant within-lag covariance between VPA and Positive Attributes HRQOL was found for one participant. The highly individual nature of the results supports the importance of investigating intra-individual change over time.

Table of Contents

Evaluating the relationship between vigorous physical activity and health related quality of life among overweight and obese children: An application of Dynamic P-Technique

Rates of overweight and obesity in the pediatric population remain high, as approximately one third of U.S. children and adolescents between the ages of 2 and 19 are overweight (as indicated by a Body Mass Index (BMI) above the 85th percentile), with roughly 17% falling in the obese category (as indicated by a BMI above the 95th percentile; Ogden, Carroll, Kit, & Flegal, 2012). Overweight and obesity are due in part to an imbalance in the energy equation: excess calories consumed relative to the number of calories expended (Goran & Treuth, 2001). Factoring into half of the energy equation, overweight and obese children and adolescents are less active (Dionne, Almeras, Bouchard, & Tremblay, 2000; Ekelund, Aman, Yngve, Renman, Westerterp, & Sjostrom, 2002) and more likely to decline in levels of physical activity faster than their normal weight peers (Kimm et al., 2002). Moreover, physical activity levels during adolescence predict activity levels during adulthood (Telama, Yang, Viikari, Valimaki, Wanne, & Raitakari, 2005). Indeed, physical activity levels during childhood and adolescence set the stage for lifetime health behavior, and among those who are already overweight or obese, compound the risk for persistent obesity throughout adulthood. It comes as no surprise that due to decreased levels of physical activity, as well as a myriad of environmental, physiologic, and genetic influences on weight, nearly one in three adults are overweight or obese, with rates still increasing (Ogden et al., 2012).

In addition to poor physical health (e.g., Daniels et al., 2005; Daniels, 2006), overweight and obese youth frequently present with compromised psychological and psychosocial functioning, including depressive symptoms, poor self-esteem and self-concept, and body dissatisfaction (Speiser et al., 2005; Jelalian & Hart, 2009). Contributing to these specific symptoms, children who are overweight or obese also present with compromised health-related quality of life (HRQOL). Quality of life has been defined as a multidimensional construct that reflects one's self-perceptions of enjoyment and satisfaction with life (Shoup, Gattshall, Dandamundi, & Estabrooks, 2008). Specifically, HRQOL, as defined by the World Health Organization as an individual's quality of life associated with their physical, mental and social well being (Williams, Wake, Hesketh, Maher & Waters, 2005), is lower among obese children than among their normal weight peers (Schwimmer, Burwinkle, & Varni, 2003; Shoup et al., 2008). In particular, obesity-specific HRQOL asks the overweight or obese child to rate his or her HRQOL in the context of physical size (Zeller & Modi, 2009), and demonstrates how physical size impacts daily functioning. And in fact, obese children rate their impairments in daily functioning at a level similar to that of children with cancer (Schwimmer et al., 2003).

Psychosocial Sequelae of Physical Activity

Contributing to the pediatric obesity epidemic, only 30% of U.S. children meet the recommended guidelines of sixty minutes of moderate/vigorous physical activity per day (Centers for Disease Control and Prevention, 2010). Beyond a risk for persistent obesity and attendant health and mental health risks, children who are less active (regardless of weight status) are at an increased risk for the psychosocial sequelae of low levels of physical activity. Correlates of physical activity among youth are fairly consistent when evaluated in cross-sectional studies: Lower levels of self-reported depressive symptoms and higher levels of self-efficacy are commonly associated with greater levels of physical activity (Sallis, Prochaska, & Taylor, 2000; DiLorenzo, Stucky-Ropp, Vander Wal, & Gotham, 1998; van der Horst, Paw, Twisk, & van Mechelen, 2007). Although limited, some research has also demonstrated that children with lower levels of physical activity, irrespective of weight status, experience significantly lower HRQOL (Shoup et al., 2008). Therefore, decreased levels of physical activity can be detrimental to HRQOL, regardless of current weight status. More consistent associations between physical activity and quality of life have been demonstrated among adults (Vuillemin et al., 2005; Penedo & Dahn, 2005), but less is known about this specific relationship among children.

Although duration of physical activity is associated with improved psychosocial functioning, it is important to also consider differences in the quality (i.e., intensity) of physical activity as a predictor of outcomes (Janssen & LeBlanc, 2010). As such, explorations of the associations between *intensity* of physical activity (i.e., light, moderate, and vigorous) and mental health correlates have emerged in the youth literature, in addition to studies of associations between quantity of physical activity and outcomes. Among middle-school children, time accumulated in vigorous activity has shown negative correlations with anxiety, behavioral conduct, and depressive symptomatology (Parfitt, Pavey, & Rowlands, 2009; Prasad, St-Hilaire, Wong, Peterson, & Loftin, 2009). Furthermore, increased vigorous physical activity is positively associated with physical self-worth (Parfitt et al., 2009). On the other hand, those spending more time in only very light activity have demonstrated increased risk for anxiety and depressive symptoms (Parfitt et al., 2009). As demonstrated by the above examples, cross-sectional investigations of time accumulated in physical activity, with an emphasis on *vigorous* physical activity, have confirmed overall positive associations with psychological health in youth. Although these findings are robust, the correlational design of the majority of studies limit the degree to which firm conclusions can be made about the association between physical activity intensity and mental health outcomes.

Measured experimentally, the impact of intensity of physical activity on youth mental health is not as clear. Two recent meta-analyses have investigated the effect of experimental manipulations of physical activity on mental health in children. Larun, Nordheim, Ekeland, Hagen and Heian (2006) conducted a meta-analysis of 16 randomized-controlled trials implementing physical activity interventions for children. The authors focused solely on the outcomes of anxiety and depression, and excluded those children who were overweight or obese. Results indicated no significant differences between vigorous, moderate, and light physical activity on children's depression and anxiety (Larun et al., 2006). However, the authors concluded that the literature examining exercise interventions in children was sparse (N=16 studies), utilized small samples sizes, and generally employed low methodological rigor.

Broadening the scope of the 2006 meta-analysis, Ahn and Fedewa (2011) conducted a meta analysis of 73 studies evaluating the effect of physical activity on mental health outcomes in children and adolescents, including both randomized experimental trials (N=54) and correlational studies (N=19), and widening the criteria of mental health outcomes to include self-esteem, distress, emotional disturbance, ADHD symptoms, somatic symptomatology, social functioning, conduct problems, cognitive problems, self-concept, and quality of life. Ahn and Fedewa (2011) also included moderator analyses to determine whether physical health status (i.e., typical, fit, or obese) presented differing effects.

Results indicated that randomized-controlled interventions designed to facilitate the highest levels of intensity of physical activity had the greatest effect (d = -0.27) on children's mental health (e.g., depression and self-esteem) as compared to the effects of light (d = -0.10) and moderate (d = -0.18) intensity physical activity. Intervention effects were equally effective for children classified as overweight/obese as well as normal weight, demonstrating the potential of physical activity to affect mental health in children, regardless of weight status (Ahn &

Fedewa, 2011). However, neither Ahn and Fedewa (2011) nor Larun et al. (2006) reported whether included studies objectively measured physical activity in participants, which may have contributed to the contradictory results. Over-reporting of moderate and vigorous physical activity is a common potential problem when using self-report measures, especially among females (Adamo, Prince, Tricco, Connor-Gorber, & Tremblay, 2009). Self-reported physical activity measures given only pre- and post-intervention do not capture fluctuations in physical activity levels during the intervention and allow for inaccurate reporting.

Limitations of the above literature

The physical activity literature documents robust cross-sectional and/or correlational associations between moderate/vigorous physical activity and psychological health (e.g., depression, self-esteem, anxiety; Ahn & Fedewa, 2011; Sallis et al., 2000). However, well-documented longitudinal information regarding the effects of intensity of physical activity on psychological factors is mixed and limited. Given the discrepant findings between the aforementioned meta-analyses, the problems associated with subjectively measured physical activity, and overall low methodological rigor in the literature, more research is needed to better understand the relationship between intensity of physical activity and mental health outcome. Most importantly, all studies included in the two meta-analyses above were evaluated at two points: pre- and post- intervention. Such a measurement design fails to allow for the possibility of changes in scores, (in this case, physical activity), at shorter (i.e., daily, weekly, monthly) intervals. In other words, pre- to post-intervention measures assume that (1) change in the variable of interest is relatively stable, and (2) understanding any changes in that variable during the intervention is less important, resulting in missed opportunities for measuring daily or weekly fluctuations in physical activity and/or psychosocial functioning.

In addition, less is known about the relationship between intensity of physical activity and changes in HRQOL among children. Research has shown that increased levels of physical activity are associated with improved quality of life (Bize, Johnson, & Plotnikoff, 2007) but has not addressed the role of vigorous physical activity in improving HRQOL among children. Given the associations between (1) lower HRQOL and obesity (Schwimmer et al., 2003), and (2) HRQOL and high levels of physical activity (Shoup et al., 2008) among youth, pediatric overweight/obesity and low levels of physical activity among children may therefore be risk factors for lower HRQOL. As such, a greater understanding of the relationship between intensity of physical activity and HRQOL would benefit the current literature.

The Proposed Study

The current literature supports cross-sectional and correlational associations between HRQOL and physical activity, but lacks evidence between them for longitudinal and dynamic associations (Shoup et al., 2008). Although the relationship between physical activity and HRQOL is potentially a dynamic (i.e., frequently changing) process, and one that may differ by short intervals of time, no study has evaluated changes in HRQOL in small durations of time. Indeed, Bize et al. (2007) and Shoup et al. (2008) have called for more rigorous research into the associations between HRQOL and changes in physical activity. Therefore, the current study is an examination of the relationship between intensity of physical activity on health related quality of life in treatment-seeking overweight and obese children and is designed to further examine the association between HRQOL and PA using more sophisticated methodologies than those available in the past.

Specifically, the current study will employ Dynamic P-Technique (DPT; Engle & Watson, 1981) to capture the dynamic interactions between HRQOL and objectively measured physical activity intensity among participants who are enrolled in a lifestyle modification intervention for overweight or obese children/adolescents and their families. Examining the association between objectively measured physical activity intensity and HRQOL in the context of a weight management program targets those children who are at an increased risk for lower HRQOL (Steele, Aylward, Jensen, Cushing, Davis, & Bovaird, 2012). Adolescence marks a critical period in development when physical activity levels decline (Kahn et al., 2008; Kimm et al., 2002). Therefore, the current study will target adolescents between 13 and 15 years of age to shed light on physical activity behavior during this age range. *It is hypothesized that vigorous physical activity will predict elevated HRQOL among overweight and obese children and adolescents.*

After gaining an understanding of the relationships between HRQOL and physical activity ideographically and longitudinally, future large-N studies may be designed in order to test these relationships in the broad pediatric overweight and obese population (Nelson, Aylward, & Rausch, 2011). Clinically, the results of this study may inform pediatric obesity intervention protocols and objectives, to not only decrease BMI among clients but also improve psychological health and health-related quality of life. Further, greater understanding of engagement in physical activity among pediatric obesity intervention participants can inform goal-setting procedures of future interventions.

Methods

Participants

Because DPT is designed to examine the associations among two or more variables in a small number of participants using multiple data points (Nelson et al., 2011) the study recruited four adolescents seeking services for treatment of pediatric obesity through the pediatric weight management program, *Positively Fit* (Steele et al., n.d.), at the University of Kansas Child and Family Services Clinic. To ensure children's safety and health, only children who were physician-approved for physical activity were enrolled. Specifically, local pediatricians were contacted and told about the study, who then referred potential participants to the research team if and only if the children were approved for increased physical activity and met inclusion criteria.

Eligibility criteria for participation included (1) the adolescent's body mass index (BMI) measured above the 85^{th} percentile for age and sex, (2) the adolescent was between the ages 13 and 15 (inclusive), (3) referral by the child's pediatrician, or approval by a pediatrician or medical professional of the participant's ability to participate in daily physical activity; (4) parent/custodial caregiver provided informed consent for treatment of the child as well as consent for study participation; and (5) parent/caregiver participated with the child in the program. Exclusion criteria included the presence of serious mental illnesses or significant developmental delay that would reasonably predict altered ability to adhere to the treatment protocol (e.g., mental retardation, schizophrenia), the current physical illness or hospitalization of the child that would interfere with session attendance or protocol adherence, or specific medical conditions (e.g., heart defects) that would preclude the individual from engaging in moderate to vigorous physical activity. Manageable and/or moderate mental illnesses (e.g., depression, anxiety) or physical conditions that would not be expected to impact treatment adherence or engagement in physical activity (e.g., diabetes) were not used as exclusion criteria.

Participant 1. Participant 1 (J.M.) was a 14-year old Caucasian female at the 93^{rd} percentile of BMI (overweight category) for her age and weight status at the beginning of treatment. J.M. attended 10 of 10 sessions of *Positively Fit* over 70 days with her caregivers.

Participant 2. Participant 2 (D.U.) was a 13-year-old Caucasian male at the 98th percentile of BMI (obese category) for his age and weight status. D.U. attended 7 of 10 sessions of *Positively Fit* over 70 days with his caregiver.

Participant 3. Participant 3 (L.H.) was a 14-year old African American female at the 98th percentile of BMI (obese category) for her age and weight status. L.H. attended 8 out of 10 sessions of *Positively Fit* over 83 days with her caregiver.

Participant 4. Participant 4 (S.M.) was a 14-year old biracial female at the 92nd percentile of BMI (overweight category) for her age and weight status. S.M. attended 9 out of 10 sessions of *Positively Fit* over 83 days with her caregiver.

Intervention

Positively Fit (Steele et al., n.d.) is a 10-week family-based group lifestyle intervention. Families participated in ten weekly sessions lasting between 60 and 90 minutes each. Sessions involved at least one parent as well as the participating child/adolescent. Sessions included physical activity goal-setting, nutrition/physical activity education, and discussions regarding behavioral strategies for promoting stimulus control, self-monitoring, and reinforcement. *Positively Fit* demonstrated significant reductions in child zBMI in a randomized controlled trial (Steele et al., 2012). Two separate group interventions were conducted due to participant availability. Participants J.M. and D.U. enrolled in Group 1, with participants L.H. and S.M. enrolled in Group 2.

Procedure

During the initial meeting with participants, participating children and parents provided informed consent and assent to participate in the study. Participants were given instructions for using the ActiGraph and iPod Touch. Participants demonstrated sufficient ability to accurately take on and off the ActiGraph, and were provided instructions for times of the day that the device should be worn (i.e., all waking hours except bathing or swimming). Participants brought the ActiGraph activity monitoring devices to weekly treatment sessions so that the data could be downloaded to a secure device. *Positively Fit* therapists encouraged increasing physical activity, tailored to the individual participants' abilities. Weekly physical activity levels were provided to participants (e.g., print-out of ActiGraph daily levels from the previous week) when requested. Recommendations for physical activity in the Positively Fit protocol did not exceed the standard recommendations of the CDC for all children (60 minutes of moderate to vigorous physical activity per day). To incentivize participation, participants (i.e., adolescents) were provided compensation. Each participant received a $15 gift certificate during the first meeting of treatment, a $5 gift certificate every other treatment session (for a total of $25), and a $20 gift card for completing the final session, returning the iPod Touch, and returning the ActiGraph.

Participants tracked daily recordings of measures of HRQOL through a personal electronic device (PED; i.e., iPod Touch). Handheld PEDs are feasible and reliable methods for collecting HRQOL data among children. Specifically, when compared to paper and pencil format of the same pediatric HRQOL measure, PEDs result in more accurate and complete reporting (Vinney, Grade, & Connor, 2011). The HRQOL instrument was uploaded to a secure online data tracking website, *SurveyGizmo* (www.surveygizmo.com). This secure website is not accessible to the public, and the stored data was only accessible to the PI through a secure personal account, accessed only with the PI's username and password. Participants were only identified to their data by a username that contained no identifying information. The PI approved this username to ensure that it did not contain any identifying information about the participant. Participants entered data via this secure website on the iPod Touches for daily completion. Participants' iPod

Touch devices were programmed with two reminders, set at 6:00 PM and 6:55 PM; participants were asked to complete the study measures by 7:00 PM each day. Participants varied in time of survey submission; however, all survey data was collected between 6:00 PM and 11:59 PM each night. This study was approved by the Human Subjects Committee – Lawrence as Study #20152.

Measures

Physical Activity. In order to accurately measure physical activity duration and intensity, physical activity was recorded with ActiGraph tracking (ActiGraph LLC, Pensacola, FL), a small monitoring device (accelerometer) worn on the non-dominant hip with an adjustable belt. The device measures raw acceleration, activity counts and vector magnitude, energy expenditure, steps taken, and physical activity intensity. The ActiGraph has been shown to be a valid measure of physical activity for adults and children (Sirard, Melanson, & Freedson, 2000). Participants were asked to wear the device during the day, except during sleeping and bathing, every day for the duration of the 10-week intervention. Intensity of physical activity was transformed according to the count guidelines used by Troiano, Berrigan, Dodd, Masse, Tilert, and McDowell (2008) which relate accelerometer counts to measured activity expenditure (Vigorous physical activity ≥ 6 MET; Moderate physical activity ≥ 3 MET; Light physical activity < 3 MET) through ActiLife software. ActiGraph raw data were collected from 7:00 AM – 11:59 PM, and valid days were those with 6 or more hours of recorded data (Davis et al., in press). GT3X models were used and set to one-minute epochs (i.e., periods) for data collection. Non-wear time was considered to be at least 10 minutes of continuous zeros and those time periods were excluded (Corder, Ekelund, Steele, Wareham, & Brage, 2008; Masse et al., 2005; Purslow et al., 2008). Standardized number of minutes engaged in VPA were used for data analyses.

HRQOL. Weight-specific Health Related Quality of Life was measured using the *Sizing Me*

Up (SMU). Participants completed the SMU via iPod Touch to the secure online data tracking website. The SMU is a 22-item weight-specific health-related quality of life measure (Zeller & Modi, 2009). The measure consists of five scales: emotional functioning; physical functioning; social avoidance; positive social attributes; and teasing/marginalization as well as a Total score (Zeller & Modi, 2009). The *Sizing Me Up* measure uniquely asks the overweight or obese child to rate his or her HRQOL in the context of physical size. Emotional Functioning targets self-perceptions of how children's size makes them feel (i.e., sad, mad, frustrated, worried) whereas the Physical Functioning scale captures self-perceptions of how size impacts daily physical activities related to comfort and ability (i.e., getting out of breath, unable to fit in desk at school). The Social Avoidance scale measures self-perception of avoiding age-specific activities due to size (i.e., avoiding gym, not going to school, feeling uncomfortable sleeping at a friend's house). The Positive Social Attributes scale focuses on self-perceptions of positive attributes in the context of size (e.g., humor, self-liking, healthiness). Finally, the Teasing/Marginalization scale measures self-perceptions of teasing by peers due to size (Zeller & Modi, 2009). Internal consistency coefficients reported for the measure range from $\alpha = 0.68$ to $\alpha = 0.85$; intraclass correlations assessing test-retest reliabilities range from .53 to .78 (Zeller & Modi, 2009). Good convergent validity has been demonstrated with general health-related quality of life, as measured by the *PedsQL* (r = .35-.65; Cushing & Steele, 2012; Varni, Seid, & Kurtin, 2001).

Missing Data

Within all data sets, a large amount of missing data was found across all variables. J.M. produced 46/70 (65.71%; 32.29% missing) valid days of physical activity measurement from ActiGraph tracking and 41/70 days (58.57%; 41.43% missing) of HRQOL measurement through *SurveyGizmo* online data entry. J.M.'s dataset evidenced 5 variables with a variance of 0 (Item numbers 11, 12, 17, 18, and 19), which were removed prior to imputation procedures. For J.M., a total of 10 days were missing data on all variables and were therefore unable to be included in final datasets, resulting in a total of 60 data points for final analyses.

D.U. produced 31/70 (44.29%; 55.71% missing) valid days of physical activity measurement from ActiGraph tracking and 34/70 (48.60%; 51.4% missing) days of HRQOL measurement through *SurveyGizmo* online data entry. D.U.'s dataset evidenced 5 variables with a variance of 0 (Item numbers 8, 11, 12, 14, and 18), which were removed prior to imputation procedures. For D.U., a total of 23 days were missing data on all variables and were therefore unable to be included in final datasets, resulting in a total of 47 data points for final analyses.

L.H. produced 42/83 (50.60%; 49.40% missing) valid days of physical activity measurement from ActiGraph tracking, and 40/83 (48.19%; 51.81% missing) days of HRQOL measurement through *SurveyGizmo* online data entry. L.H.'s dataset evidenced 5 variables with a variance of 0 (Item numbers 11, 12, 17, 19, and 22), which were removed prior to imputation procedures. For L.H., a total of 27 days were missing data on all variables and were therefore unable to be included in final datasets, resulting in a total of 57 data points for final analyses.

S.M. produced 28/83 (33.73%; 66.27% missing) valid days of physical activity measurement from ActiGraph tracking, and 39/83 (46.99%; 53.01% missing) days of HRQOL measurement through *SurveyGizmo* online data entry. S.M.'s dataset evidenced 8 variables with a variance of 0 (Item numbers 1, 5, 11, 12, 15, 18, 19, and 22), which were removed prior to imputation procedures. For S.M., a total of 30 days were missing data on all variables and were therefore unable to be included in final datasets, resulting in a total of 53 data points for final analyses.

Participants reported that data was missing because they often "forgot" or because the survey website did not register their submission. As such, missing data was determined to be Missing Completely at Random (MCAR; Little, 2013), which means that the "missingness" is not related to any other variables in the dataset and is therefore appropriate for modern missing data techniques (Aylward, Anderson, & Nelson, 2010). Multiple Imputation (MI) was completed to recover missing data. The EM algorithm through MPlus was used to create 100 datasets per participant to be used in the final analyses. The EM algorithm utilizes the totality of the raw data in order to impute the missing data, which increases the likelihood of using unbiased data (Enders, 2010). Across all participants, the MI procedure was not applied to days in which both HRQOL and VPA scores were missing.

Analytic Procedures

Dynamic P-Technique (DPT; Engle & Watson, 1981) was used to evaluate the degree to which vigorous physical activity (VPA) was associated with HRQOL in adolescents seeking treatment for pediatric obesity. DPT is a statistical method useful for examining relationships among dynamic constructs in a single individual or small group of individuals over time. As noted by Little, Bovaird, and Slegers (2006) and Nelson et al. (2011), DPT derives its statistical power from a large number of observations over time and is useful when employed with a small number of participants. DPT is particularly useful for examining how different variables relate to each other at the same time, how the same variable relates to itself over time, and how one variable relates to another longitudinally (Nelson et al., 2011). DPT was particularly indicated in the current study as a statistically rigorous option for evaluating the associations between PA and HRQOL, because experimental manipulation of key variables was not possible, and because of the potential for the variable of interest to affect itself across time. Increased levels of vigorous physical activity were hypothesized to be associated with HRQOL over time.

The idiographic nature of DPT enables participants to be considered as separate groups; therefore, participant data was evaluated in separate datasets to create individual models (i.e., J.M. as an individual data set, etc.). Confirmatory factor analysis (CFA) was completed for each dataset to confirm the hypothesized structure of the subscales of HRQOL and to assess the hypothesized structure of HRQOL and Vigorous Physical Activity (VPA). A CFA was conducted for each participant in which all subscales of *Sizing Me Up* (e.g., Teasing HRQOL, Positive Attributes HRQOL, Social HRQOL, Emotional HRQOL, and Physical HRQOL) were set as latent variables. VPA was represented by a single indicator since it is a total score (i.e., number of minutes in VPA per day). Five items from *Sizing Me Up* were excluded from analyses (items 11, 12, 14, 18, and 22), because of lack of opportunity for daily fluctuations (i.e., the event could not likely occur on a daily basis; e.g., "a sleep over at a friends house"). Vigorous physical activity (VPA) was standardized (i.e., rescaled to have a mean of zero and a standard deviation of one) in order to reduce the large discrepancy of scale between variables. Because VPA is represented by a single manifest variable (i.e., number of minutes in VPA per day), the loading was set to a value of 1.0 with a residual variance of 0.0. All residual variances were allowed to correlate.

When using latent parameters, it is impossible to know how all of the parameter estimates relate to each other if they are allowed to freely estimate. However, if an estimate of the measurement model is "set," then it is possible to interpret the remaining parameters in reference to this "set" parameter; this is the method of setting the scale. The fixed factor method of scaling was employed to set the scale of the confirmatory factor models, which fixes the variance of the latent variables to 1.0. Effects coding was employed to set the scale of the lagged models. This method does not fix any individual indicators or latent factors, but instead balances the loadings of the indicators to average 1.0 (Little, Slegars, & Card, 2006). Within-subject tests of invariance are not indicated in P-technique factor analysis (Little, 2013), given the assumption that each participant is a single "group," and therefore were not conducted for these analyses.

Model fit statistics are included for each model to evaluate the degree to which the hypothesized (implied) model fit the observed data. All models were evaluated by examining the χ^2 test of significance, which provides a precise measure of the difference between the implied model and observed data, with significant values implying a significant difference between the models. However, because the χ^2 statistic is sensitive to large degrees of freedom, additional measures of model fit are included (Little, 2013). All models were also evaluated by the Comparative Fit Index (CFI), Tucker-Lewis Index (TFI), Root Mean Squared Error of Approximation (RMSEA), and Standardized Root Mean-Square Residual (SRMR). Model fit was considered to be acceptable for CFI and TFI values above 0.90, and good for values above 0.95 (Little, 2013). Model fit was considered to be acceptable if the RMSEA and SRMR values were below 0.08, and good if values were below 0.05 (Little, 2013).

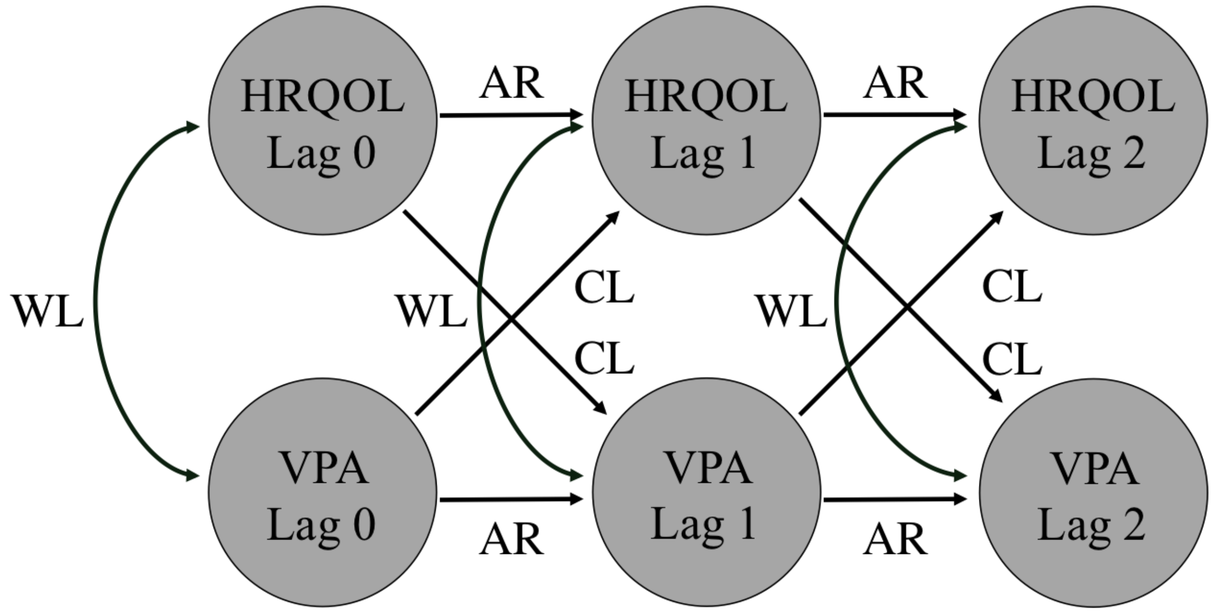

Figure 1. Proposed dynamic model structure (WL = Within-lag relationships; AR = Autoregressive relationships; CL = Cross-lagged relationships).

In order to test the dynamic relations (i.e., lagged effects) between HRQOL subscales and VPA, datasets were manipulated to include lagged variables (e.g., 0, 1, and 2 lags) and a test of lagged effects was conducted for each participant. Variables included in lagged analyses were: (1) Minutes spent in vigorous physical activity (VPA), (2) Teasing, Positive Attributes, Social, Emotional, and Physical Functioning subscales of HRQOL, and (3) Time (i.e., Day 1, 2, 3 … 70 or 83). Minutes spent in VPA and HRQOL were analyzed according to autoregressive relationships (AR), within-lag relationships (C), and cross-lagged relationships (CL; Lee & Little, 2012). Autoregressive relationships analyze the extent to which a variable affects itself over time (e.g., HRQOL on Day 1 predicts HRQOL on Day 2; lag of 1). Within-lag relationships examine the covariance between two variables at the same time (e.g., HRQOL on Day 1 and VPA on Day 1; lag of 0). Finally, cross-lagged relationships evaluate the associations between the variables over time (e.g., VPA on Day 1 with HRQOL on Day 2; lag of 1). Time was used to determine the length of the lag for the autoregressive and cross-lagged paths. See Figure 1 for a visual representation of the proposed model.

Results

The following results reflect model fit statistics, covariance values, and regression weight values between tested variables. Descriptive information at the participant level (i.e., range, minimum, maximum, mean, standard deviation, and variance values) for VPA and HRQOL is included in the Appendix.

Measurement Models

J.M. The initial model included all indicators except those without possibility for daily fluctuations (i.e., items 14 and 22; items 11, 12, and 18 were also not included in the final dataset because of zero variance). The model included 2 indicators of Teasing HRQOL, 4 indicators of Emotional HRQOL, 4 indicators of Physical HRQOL, and 5 indicators of Positive Attributes HRQOL. In accordance with multiple imputation procedures, it is necessary to replicate all imputed datasets for each model; in all models, 100 datasets were imputed and therefore necessary to replicate. The initial model resulted in 22/100 replicated datasets, which suggests that the model specified still did not properly fit the data. Upon further examination, 2/2 items for Teasing and 1/5 item for Positive Attributes did not load significantly onto the respective latent constructs, and were therefore removed from the model. With Emotional HRQOL, Physical HRQOL, and Positive Attributes HRQOL included, results indicated poor model fit ($\chi^2_{(62,\ n=60)}$ = 327.531, p = 0.000; RMSEA = .267 (*0.239, 0.296*); CFI = 0.541; TLI = 0.423; SRMR = 0.350). With only Emotional HRQOL and Positive Attributes HRQOL in the model, results still indicated poor fit ($\chi^2_{(25,\ n=60)}$ = 108.268, p = 0.000; RMSEA = .236 (*0.191, 0.282*); CFI = 0.761; TLI = 0.655; SRMR = 0.096). Including only Emotional HRQOL and VPA in the model improved results slightly ($\chi^2_{(25,\ n=60)}$ = 27.426, p = 0.000; RMSEA = .273 (*0.179, 0.378*); CFI = 0.876; TLI = 0.752; SRMR = 0.045). Including only Positive Attributes HRQOL and VPA in the model produced the best fitting results ($\chi^2_{(5,\ n=60)}$ = 8.440, p = 0.1336; RMSEA = 0.107 (*0.000, 0.228*); CFI = 0.961; TLI = 0.922; SRMR = 0.049). The final model included Positive Attributes HRQOL as identified by 4 indicators (items 3, 7, 8, and 13), and Vigorous Physical Activity (VPA) as a latent variable with a single indicator (i.e., minutes of VPA per day). See Figure 2 for a visual depiction of the CFA for J.M.

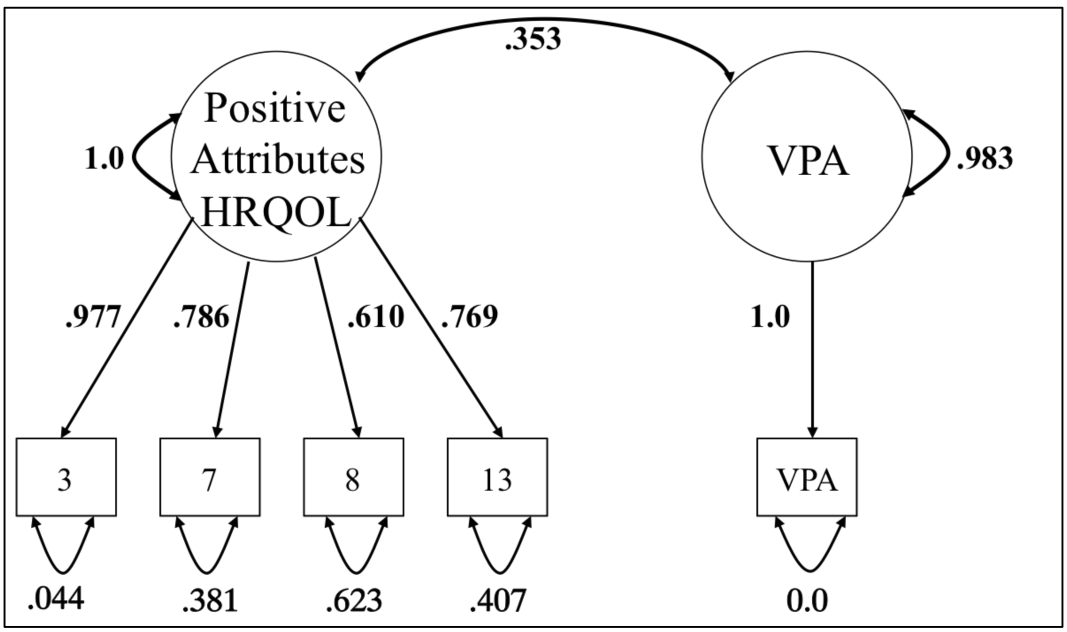

Figure 2. Confirmatory Factor Analysis for J.M. (Participant 1).

D.U. The initial model included all indicators except those without possibility for daily fluctuations (i.e., item 22; items 11, 12, 14, and 18 were not included in the final dataset because of zero variance). With the remaining variables included, the measurement model did not converge (i.e., no datasets were replicated) because of significant problems with the covariance between Teasing and VPA. When Teasing was removed from the model, MPlus did not replicate all 100 datasets, which suggests that the model specified still did not properly fit the data. Upon further examination, 3 of 3 indicators for Positive Attributes did not load significantly onto the latent construct, and were thus removed from the model. With Physical, Emotional, Social, and VPA included in the model, 99 of 100 datasets were replicated; items 20 and 21 were removed because of non-significant loadings. Because of the inadequate number of items remaining for Physical and Social (Physical 2/5 and Social 2/5), both constructs were also removed from the model. The final model included Emotional HRQOL as identified by 4 indicators (items 2, 4, 9, 10), and Vigorous Physical Activity (VPA) as a latent variable with a single indicator (i.e., minutes of VPA per day). Results indicated good model fit ($\chi^2_{(5,\ n=47)}$ = 5.169, p = 0.40; RMSEA = 0.027 (*0.000, 0.206*); CFI = 0.999; TLI = 0.997; SRMR = 0.030). See Figure 3 for a visual depiction of the CFA for D.U.

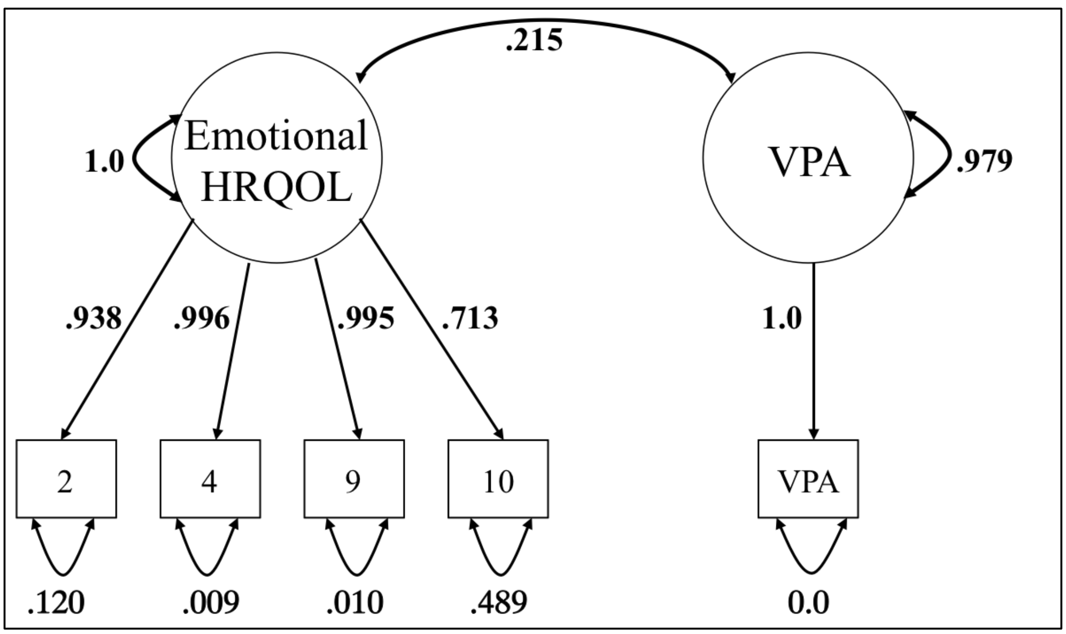

Figure 3. Confirmatory Factor Analysis for D.U. (Participant 2).

L.H. The initial model included all indicators except those without possibility for daily fluctuations (i.e., items 14 and 18; items 11, 12, and 22 were not included in the final dataset because of zero variance). For L.H., Social HRQOL was not included in the initial model because of zero remaining indicators for the latent construct Social. With the remaining variables included, MPlus did not replicate all 100 datasets, which suggests that the model specified still did not properly fit the data. Upon further examination, 2 of 2 indicators for Teasing, 1 of 4 indicators of Physical, and 3 of 5 indicators of Positive Attributes did not load significantly onto the respective latent constructs, and were thus removed from the model. Because of the inadequate number of items remaining for Positive Attributes (2/5), it was removed from the model. With Emotional HRQOL as identified by 4 indicators, Physical as identified by 3 indicators, and Vigorous Physical Activity (VPA) as a latent variable with a single indicator (i.e., minutes of VPA per day), the model indicated mediocre fit ($\chi^2_{(28,\ n=56)} = 31.38$, $p = 0.02$; RMSEA = 0.115 (*0.040, 0.181*); CFI = 0.900; TLI = 0.844). The latent construct Physical HRQOL was pruned from the model, which significantly improved model fit. Results of the final model indicated very good model fit ($\chi^2_{(5,\ n=57)} = 3.251$, $p = 0.66$; RMSEA = 0.0 (*0.000, 0.148*); CFI = 1.000; TLI = 1.080; SRMR = 0.036), with Emotional HRQOL as identified by 4 indicators (items 2, 4, 9, and 10), and VPA as a latent variable with a single indicator included. See Figure 4 for a visual depiction of the CFA for L.H.

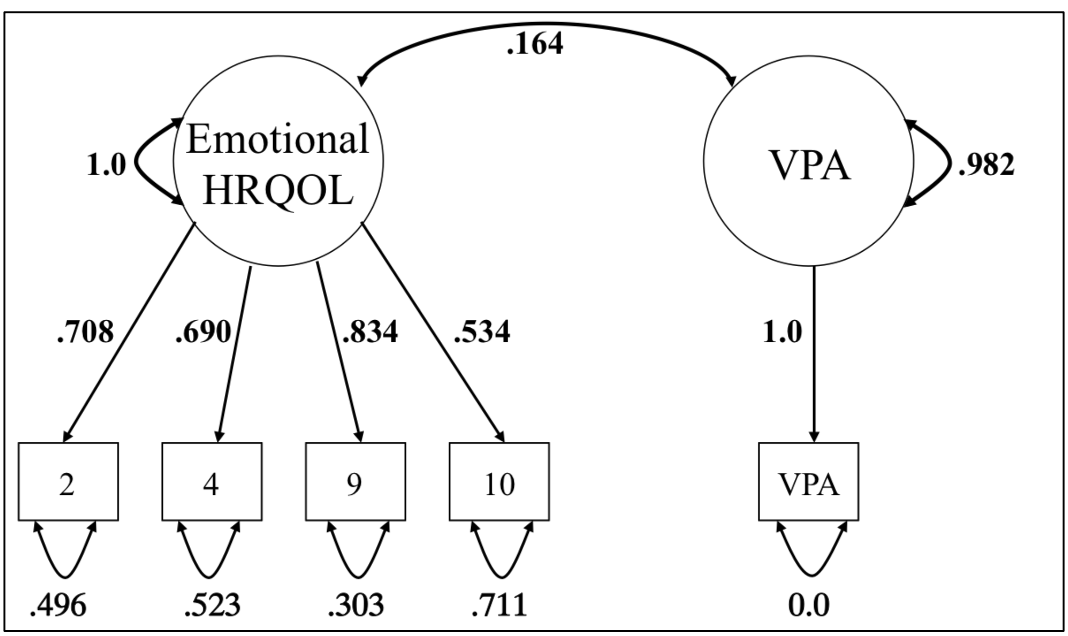

Figure 4. Confirmatory Factor Analysis for L.H. (Participant 3).

S.M. The initial model included all indicators except those without possibility for daily fluctuations (i.e., item 14; items 11, 12, 18, and 22 were not included in the final dataset because of zero variance). For S.M., Social was not included in the initial model because of inadequate number of items for the latent construct (1/5), and Teasing because of zero available indicators for the latent construct. With the remaining variables included, MPlus did not replicate all 100 datasets, which suggests that the model specified still did not properly fit the data. Upon further examination, 3 of 3 indicators for Emotion, 1 of 3 indicators of Physical, and 1 of 5 indicators of Positive Attributes did not load significantly onto the respective latent constructs, and were thus removed from the model. Because of the inadequate number of items remaining for Physical (2/5), the latent construct removed from the model. Therefore, with Positive Attributes as identified by 4 indicators (items 3, 7, 13, and 16), and Vigorous Physical Activity (VPA) as a latent variable with a single indicator (i.e., minutes of VPA per day), the final model indicated very good fit ($\chi^2_{(5,\, n=53)} = 2.148$, $p = 0.83$; RMSEA = 0.000 (*0.000, 0.113*); CFI = 1.000; TLI = 1.197; SRMR = 0.036). See Figure 5 for a visual depiction of the CFA for S.M.

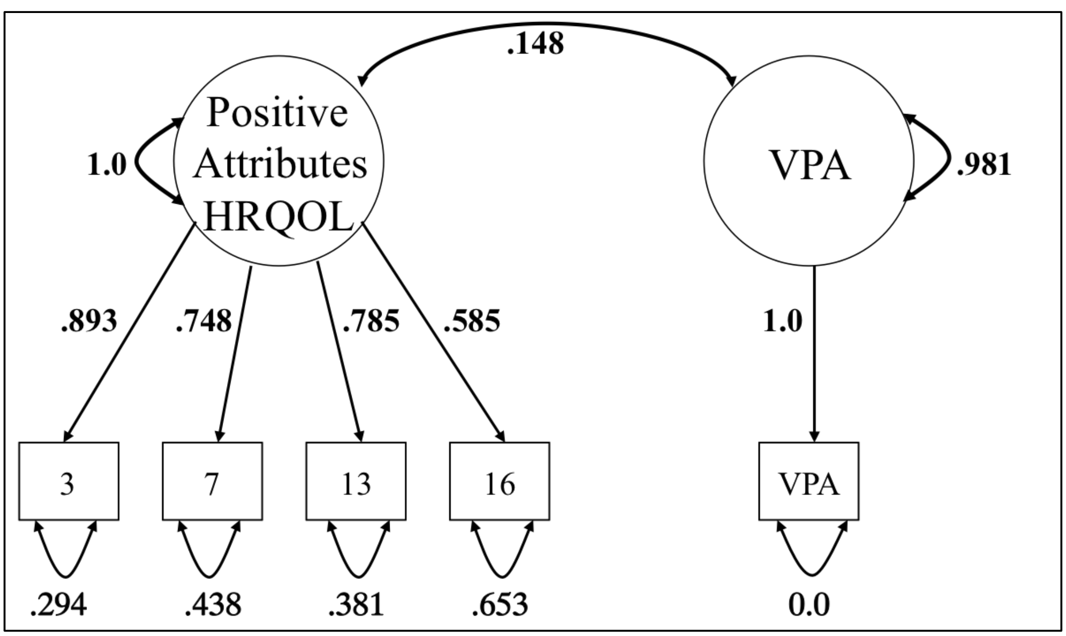

Figure 5. Confirmatory Factor Analysis for S.M. (Participant 4).

Overall, confirmatory factor analyses did not confirm the original 5-factor structure of *Sizing Me Up* for any participant. Across all participants, the subscales Teasing/Marginalization, Physical, and Social Avoidance did not hold their factor structure across time. There were several items that indicated zero variance across all participants, and a few items that were invariant on an individual participant basis. The measurement models for J.M. and S.M. confirmed Positive Attributes HRQOL as the only valid latent subscale of HRQOL, whereas the measurement models for D.U. and L.H. included only Emotional HRQOL in the final models. All measurement models demonstrated excellent model fit, which suggests that editing models at the individual level (as opposed to grouping the participants together) significantly improved the validity of the results. Interestingly, the models for Emotional HRQOL resulted in identical items (e.g., items 2, 4, 9, 10); however, the models for Positive Attributes HRQOL evidenced differing items. For example, J.M.'s final model resulted in items 3, 7, 8, and 13, whereas S.M.'s final model included items 3, 7, 13, and 16, even though both were capturing Positive Attributes HRQOL.

Structural Models

J.M. The lagged dataset for J.M. included Positive Attributes HRQOL and VPA, set to lags of 0, 1, and 2, which indicated a total lag of 2 days. Positive Attributes HRQOL was set to regress on Positive Attributes HRQOL from one and two days prior (autoregressive paths) as well as VPA from one and two days prior (cross-lagged relationships). Additionally, Positive Attributes HRQOL was set to co-vary with VPA to assess within-lag relationships. To test for the directionality of the effects, VPA was set to regress on Positive Attributes HRQOL from one and two days prior (cross-lagged relationships). VPA was set to regress on VPA from one and two days prior (autoregressive paths).

Results indicated mediocre model fit, ($\chi^2_{(91,\ n=60)}$ = 141.303, p = .0006; RMSEA = .094 (.062, 0.124); CFI = 0.796; TLI = 0.764; SRMR = 0.246). The cross-lagged hypotheses between HRQOL and VPA were not supported; however, the within-lag covariance between VPA Lag 0 and Positive Attributes HRQOL Lag 0 was significant (.290, p = 0.009). In support of study hypotheses, this suggests that for J.M., higher levels of VPA predict higher levels of Positive Attributes HRQOL that same day. VPA Lag 0 did not significantly predict VPA Lag 1 (B = 0.035; p > 0.05) or Lag 2 (B = .043; p > 0.05), and did not significantly predict Positive Attributes HRQOL Lag 1 (B = -0.029; p > 0.05) or Lag 2 (B = -0.084; p > 0.05). Similarly, Positive Attributes HRQOL Lag 0 did not significantly predict VPA Lag 1 (B = 0.172; p > 0.05) or Lag 2 (B = 0.099; p > 0.05). However, significant autoregressive paths were found for Positive Attributes HRQOL, such that Positive Attributes HRQOL Lag 0 significantly predicted higher Positive Attributes HRQOL Lag 1 (B = 0.548, p = .000), which then predicted higher Positive Attributes HRQOL Lag 2 (B = 0.590, p = .000). See Figure 6 for a visual representation of the within-lag covariance and autoregressive relationships.

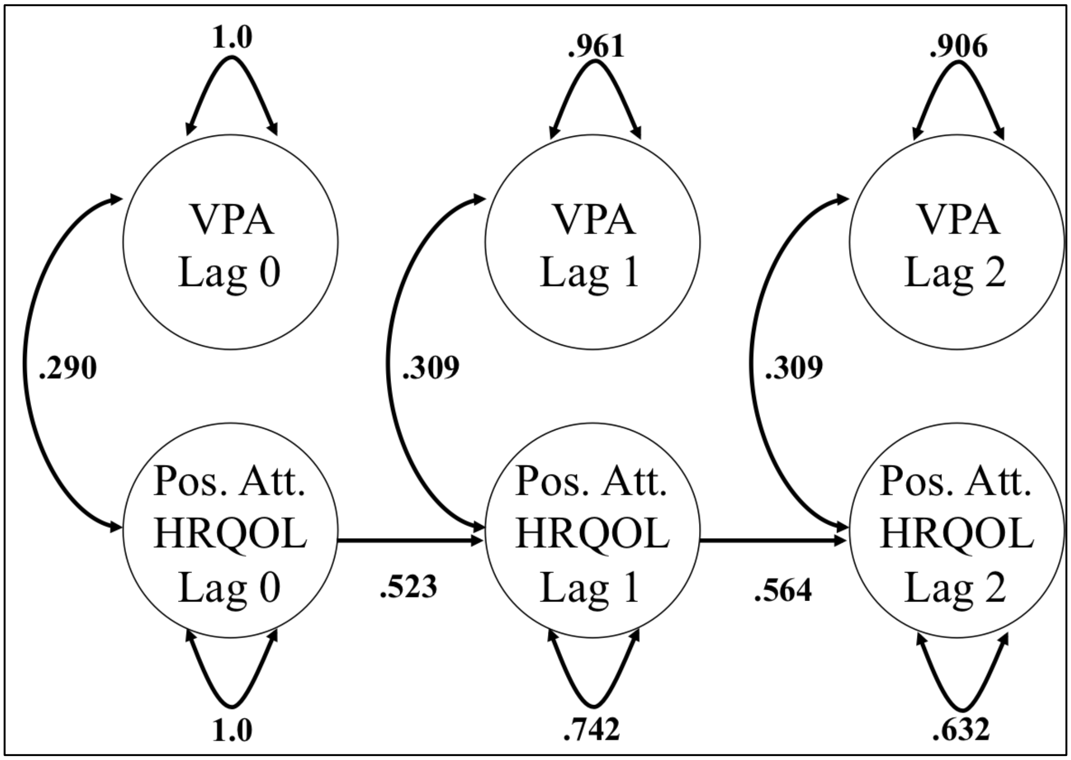

Figure 6. Graphic of significant relationships between VPA and Positive Attributes HRQOL for J.M. Results demonstrated significant positive within-lag covariance between VPA and Positive Attributes HRQOL, and significant positive autoregressive paths for Positive Attributes HRQOL.

D.U. The lagged dataset for D.U. included Emotional HRQOL and VPA, set to lags of 0, 1, and 2, which indicated a total lag of 2 days. Emotional HRQOL was set to regress on Emotional HRQOL from one and two days prior (autoregressive paths) as well as VPA from one and two days prior (cross-lagged relationships). Additionally, Emotional HRQOL was set to co-vary with VPA to assess within-lag relationships. To test for the directionality of the effects, VPA was set to regress on Emotional HRQOL from one and two days prior (cross-lagged relationships). VPA was set to regress on VPA from one and two days prior (autoregressive paths). Results indicated good model fit ($\chi^2_{(89,\ n=52)} = 23.530$, $p = 1.000$; RMSEA = .000 (.000, .000); CFI = 1.0; TLI = 1.239; SRMR = 0.072); however, results for D.U. did not support study hypotheses. The covariance between VPA Lag 0 and Emotional HRQOL Lag 0 was not significant (0.142, p >

0.05). VPA Lag 0 did not significantly predict VPA Lag 1 (B = -0.074; $p > 0.05$) or Lag 2 (B = -0.021; $p > 0.05$), and did not significantly predict Emotional HRQOL Lag 1 (B = -0.076; $p > 0.05$) or Lag 2 (B = 0.045; $p > 0.05$). Similarly, Emotional HRQOL Lag 0 did not significantly predict VPA Lag 1 (B = 0.017; $p > 0.05$) or Lag 2 (B = 0.205; $p > 0.05$), and did not significantly predict Emotional HRQOL Lag 1 (B = 0.182, $p > 0.05$) or Lag 2 (B = -0.106, $p > 0.05$).

L.H. The lagged dataset for L.H. included Emotional HRQOL and VPA, set to lags of 0, 1, and 2, which indicated a total lag of 2 days. Emotional HRQOL was set to regress on Emotional HRQOL from one and two days prior (autoregressive paths) as well as VPA from one and two days prior (cross-lagged relationships). Additionally, Emotional HRQOL was set to co-vary with VPA to assess within-lag relationships. To test for the directionality of the effects, VPA was set to regress on Emotional HRQOL from one and two days prior (cross-lagged relationships). VPA was set to regress on VPA from one and two days prior (autoregressive paths). Results indicated good model fit ($\chi^2_{(89, n=58)} = 22.396$, $p = 1.000$; RMSEA = .000 (.000, .000); CFI = 1.0; TLI = 2.136; SRMR = 0.053). Results for L.H. did not support hypotheses between HRQOL and VPA; however, significant autoregressive relations were found. The covariance between VPA Lag 0 and Emotional HRQOL Lag 0 was not significant (0.328, $p > 0.05$). VPA Lag 0 did not significantly predict VPA Lag 1 (B = -0.026; $p > 0.05$) or Lag 2 (B = -0.003; $p > 0.05$), and did not significantly predict Emotional HRQOL Lag 1 (B = -0.012; $p > 0.05$) or Lag 2 (B = 0.059; $p > 0.05$). Similarly, Emotional HRQOL Lag 0 did not significantly predict VPA Lag 1 (B = -0.123; $p > 0.05$) or Lag 2 (B = 0.044; $p > 0.05$). However, significant autoregressive paths were found for Emotional HRQOL, such that Emotional HRQOL Lag 0 significantly predicted higher Emotional HRQOL Lag 1 (B = 0.353, $p = .011$), which then predicted higher Emotional HRQOL Lag 2 (B = 0.374, $p = .023$). See Figure 7 for a visual representation of the autoregressive relationships.

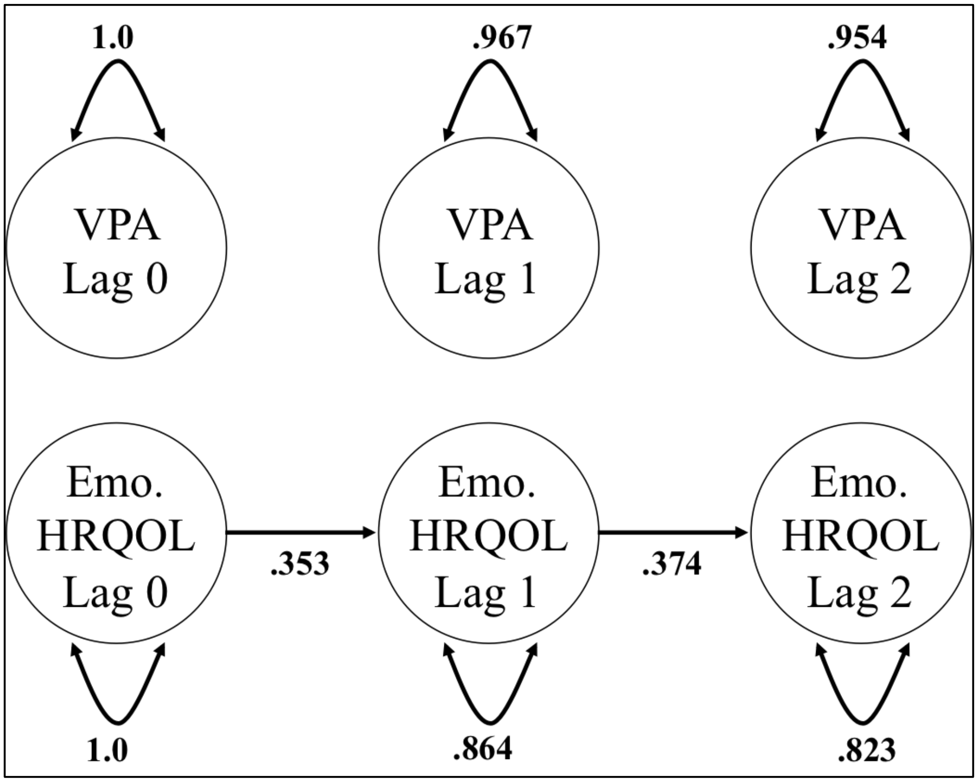

Figure 7. Graphic of significant positive autoregressive relationships between among Positive Attributes HRQOL for L.H.

S.M. The lagged dataset for S.M. included Positive Attributes HRQOL and VPA, set to lags of 0, 1, and 2, which indicated a total lag of 2 days. Positive Attributes HRQOL was set to regress on Positive Attributes HRQOL from one and two days prior (autoregressive paths) as well as VPA from one and two days prior (cross-lagged relationships). Additionally, Positive Attributes HRQOL was set to co-vary with VPA to assess within-lag relationships. To test for the directionality of the effects, VPA was set to regress on Positive Attributes HRQOL from one and two days prior (cross-lagged relationships). VPA was set to regress on VPA from one and two days prior (autoregressive paths). Results indicated good model fit ($\chi^2_{(89,\ n=55)} = 32.371$, $p =$ 1.000; RMSEA = .000 (.000, .000); CFI = 1.0; TLI = 1.993; SRMR = 0.070). Results for S.M.

did not support study hypotheses. The covariance between VPA Lag 0 and Positive Attributes HRQOL Lag 0 was not significant (0.143, $p > 0.05$). VPA Lag 0 did not significantly predict VPA Lag 1 (B = -0.030; $p > 0.05$) or Lag 2 (B = -0.008; $p > 0.05$), and did not significantly predict Positive Attributes HRQOL Lag 1 (B = -0.065; $p > 0.05$) or Lag 2 (B = 0.168; $p > 0.05$). Similarly, Positive Attributes HRQOL Lag 0 did not significantly predict VPA Lag 1 (B = 0.261; $p > 0.05$) or Lag 2 (B = 0.105; $p > 0.05$), and did not significantly predict Positive Attributes Lag 1 (B = 0.225, $p > 0.05$) or Lag 2 (B = 0.148, $p > 0.05$).

Overall, the final models testing within-lag, autoregressive, and cross-lagged relationships revealed significant differences between the four participants. Across all participants, the cross-lagged effects of VPA on HRQOL, and HRQOL on VPA were non-significant. This means that no lagged effects were detected, such that VPA did not significantly predict HRQOL one or two days later, and vice versa. When examining the autoregressive relationships, or the influence of a variable on itself over time, significant effects emerged. Although no autoregressive effects of VPA were found for any participant, HRQOL appeared to influence itself through an autoregressive path. For J.M., Positive Attributes HRQOL yesterday (Lag 0) significantly predicted increased Positive Attributes HRQOL today (Lag 1), which then predicted an increase on tomorrow's Positive Attributes HRQOL (Lag 2). The same predictive pattern held for Emotional HRQOL with L.H. The only participant to demonstrate significant within-lag relationships was J.M., who demonstrated significant covariance between VPA and Positive Attributes HRQOL Lag 0; this relationship suggested that higher levels of VPA predict higher levels of Positive Attributes HRQOL that same day, which supported study hypotheses.

Discussion

Previous evaluations of Health Related Quality of Life have examined this construct utilizing traditional methods of large-N cross-sectional or pre-post designs. Large-N evaluations are essential for generalizing results across a large number of individuals to establish patterns, detecting generalized associations, and developing meaningful effect sizes among variables. Developments such as multiple group, hierarchical, and growth curve modeling have advanced our understanding of differences among qualitatively different groups, cross-sectionally and over time. However, alternative methods are available for examining the interactions of constructs across time without forfeiting the variability associated with the individual. Dynamic P-Technique is one such technique that has thus far been underutilized in pediatric populations (Nelson, Aylward, & Rausch, 2011). Given the associations between HRQOL and physical activity established in the literature, the current study examined those associations among a small number of individuals utilizing a technique to capture changes and associations over time and at the individual level.

The results comprised daily records of HRQOL and physical activity from four overweight or obese adolescents enrolled in a family-based weight management program. Given the idiographic nature of this research, all analyses were completed separately for each of the four participants. The original 5-factor model structure of HRQOL (*Sizing Me Up;* Zeller & Modi, 2009) did not hold for the initial confirmatory factor analyses for any of the 4 participants. For 2 participants, only Emotional HRQOL held its factor structure across the duration of the intervention, whereas only Positive Attributes HRQOL held for the other two. The differences in model fit and factor structures demonstrate the idiographic nature of HRQOL for individuals and the usefulness of testing the models separately using P-technique. Whereas previously published group-level factor analytic results are essential for assessing the reliability and validity of HRQOL across multiple individuals at one point in time (e.g., Cushing & Steele, 2012; Zeller &

Modi, 2009), the results of this study suggest that Emotional and Positive Attributes HRQOL also have the potential for holding their factor structure when measured frequently (i.e., daily) over time at the individual level.

Structural Models

The results of the structural (tested) models evidenced tremendous variability. The results of the tested autoregressive relationships for VPA and HRQOL produced significant findings for two of four participants, and null findings for the remaining two participants. J.M. demonstrated that her rating of Positive Attributes HRQOL yesterday predicted her ratings today, which then predicted tomorrow’s ratings. The same pattern held for L.H.’s Emotional HRQOL. For J.M. and L.H., this predictable pattern follows a simplex pattern of association, wherein HRQOL predicts changes in itself from one day to the next, but yesterday’s ratings did not independently predict tomorrow’s ratings. This means that for J.M., the qualities of Positive Attributes HRQOL built on themselves to predict that J.M. rated her positive attributes higher the next day, which then predicted elevated ratings the day after. Similarly for L.H., a higher rating on Emotional HRQOL today predicted a higher rating (less impairment) tomorrow and the day after.

For both participants (J.M. and L.H.), there appears to be some mechanism of the positive effects of the previous day onto the next. The results of the autoregressive relationships demonstrate the potential for variability in Emotional and Positive Attributes HRQOL among some participants. These results suggest that future large-N studies may seek to evaluate changes in HRQOL within a larger sample by allowing for more frequent measurements of HRQOL within the context of a weight management program. For example, interventions measuring weekly nutrition or physical activity changes may also measure weekly changes in HRQOL; this longer period of time may allow for more meaningful changes in targeted constructs that could be evaluated at the group level, which would provide potentially generalizable results. Capturing weekly changes would also allow for the possibility of cumulative effects of physical activity, whereas the current study does not allow for such analyses. Assessing for the effects of weekly or monthly changes among participants in large-N studies may also allow detection of dose effects, moderating effects for more individualized future treatment recommendations.

The within-lag tests of covariance assessed whether VPA would predict HRQOL within the same day. J.M. produced results demonstrating a significant covariance between VPA and Positive Attributes HRQOL *within the same day* (Fig. 6). As hypothesized, the significant relationship between VPA and Positive Attributes HRQOL suggests that higher levels of VPA predict higher levels of Positive Attributes HRQOL for certain individuals. This result supports previous literature that has found a positive relationship between physical activity and self-esteem (Tremblay, Inman, & Willms, 2000; Strauss, Rodzilsky, Burack, & Colin, 2001). It may be that engagement in vigorous physical activity has a direct positive effect on perceptions of self through biological pathways (e.g., beta-endorphins; Dinas, Koutedakis, & Flouris, 2011) and, in turn, physical self esteem (Whitehead & Corbin, 1997). Alternatively, higher levels of vigorous physical activity may also indicate additional positive influences on a child's life. For example, sports teams are associated with improved confidence, social skills, emotion regulation (Holt, Kingsley, Tink, & Scherer, 2011), and this participant may have engaged in group sports or physical education, which produced more vigorous physical activity as well as influencing her perceptions of self.

While this result supports previously demonstrated associations between physical activity and better overall HRQOL (Shoup et al., 2008), it is specific to the subscale of HRQOL that captures positive attributes of one's body size (e.g., "I feel happy because of my size"), which appear to fluctuate independently from negative perceptions of one's size (e.g., Emotional HRQOL; e.g., "I feel sad because of my size"). No significant within-lag relationships were found for VPA and Emotional HRQOL, which implies that the relationship between physical activity and quality of life may be a more complicated process than predicted. For one participant (J.M.; see Fig. 6), vigorous physical activity appears to predict elevated HRQOL specific to her positive attributes about size, but not about her emotions surrounding size. Data from two participants suggest that Emotional HRQOL may fluctuate on a daily basis; however, factors other than VPA appear to drive those changes.

Tests of cross-lagged analyses were less interesting, since no tested relationships were statistically significant. Although the literature indicated that increases in VPA should predict increased HRQOL (Shoup et al., 2008), results demonstrated that VPA and HRQOL do not dynamically interact across time within the four individual adolescents sampled for the current analyses. All tests of lagged effects of VPA on HRQOL were exploratory in nature, since no previous literature has examined HRQOL at intervals more frequent than pre-post intervention (i.e., several weeks to several months; Griffiths, Parsons, & Hill, 2010) and could therefore not inform the current analyses. Research evaluating pre to post changes in HRQOL utilizes cumulative change over a given period of time (e.g., length of an intervention), whereas the current study depended on variation of the targeted construct (i.e., HRQOL) throughout the intervention. Given the results, further examination of HRQOL with VPA is not recommended for future research utilizing Dynamic P-Technique.

Overall, results of the path models revealed a positive within-lag association between Positive Attributes HRQOL and VPA for one participant. Additionally, results of autoregressive analyses demonstrated significant autoregressive effects of HRQOL among two participants, such that Emotional and Positive Attributes HRQOL predicted increases in HRQOL in a simplex pattern, one and two days later. In other words, for two participants, yesterday's HRQOL ratings predicted elevated ratings for today, which then predicted elevated ratings for tomorrow. Finally, results of cross-lagged analyses revealed no significant lagged effects of VPA on HRQOL, or of HRQOL on VPA for any of the four participants. This suggests that yesterday's VPA does not predict changes in today's or tomorrow's HRQOL, or vice versa.

Although results are premature for clinical interpretation, they do suggest that changes in HRQOL may follow a stable pattern. This means that there is a consistent change process, or that change in HRQOL is attributable to prior levels of that variable. Clinically, the stable change pattern of HRQOL for some individuals may represent changes that correlate with treatment components that are also cumulative (i.e., cumulative changes in physical activity, diet, social support, or self efficacy). Therefore, it may be helpful to emphasize the importance of consistent adherence to treatment components. Because changes in HRQOL may be cumulative, these changes may be more apparent when measured over longer intervals (i.e., weekly or monthly). However, as evidenced by the significant within-lag results, other individuals may also see immediate benefits of VPA on HRQOL that same day. Clinicians may interpret these findings as support for tracking an individual client's physical activity and HRQOL throughout treatment. Demonstrating that today's levels of vigorous physical activity may lead to better HRQOL could serve as motivation or evidence for immediate benefits to exercise, which may help overcome the challenges associated with implementing a new exercise protocol.

Measurement Models

Beyond examination of path models, the results of the measurement models indicate that the five factors of HRQOL perform uniquely in the latent space. For all five factors of HRQOL, changes in the individual factors may occur at the indicator (i.e., individual variable) level or in the latent space (i.e., construct level), meaning that items may change on their own (i.e., indicator level), or as a factor group (i.e., construct level). For the participants in this study, Emotional HRQOL and Positive Attributes HRQOL were clearly captured well in the latent space. However, the remaining factors (i.e., Physical HRQOL, Teasing HRQOL, and Social HRQOL) were not captured well in the latent space and were therefore inappropriate for this type of analysis. Several reasons may account for the poor fit of those factors. First, three items from the Social HRQOL factor did not allow for valid daily fluctuations (e.g., “sleeping at a friend’s house”, “being picked for recess”). Those five items were removed from analyses, because levels of variance would be inaccurately attributed to processes within the individual, even though many (if not all) of such fluctuations may have been due simply to environmental (e.g., attending school) factors. Therefore, the Social HRQOL factor was left with too few items for analyses and was removed from all models. Use of Social HRQOL in future intra-individual investigations is not recommended due to the aforementioned limitations.

Second, other items demonstrated zero variance across the entirety of the interventions. Zero variance indicates either no impairment, or no change in impairment for that participant. Items without variance are inappropriate for P-Technique factor analysis. While certain items were invariant for all participants (e.g., item #11, “Chose not to go to school because of your size” and #12, “Had problems fitting into your desk at school because of your size”), other items were uniquely invariant depending on the participant. For example, D.U. indicated no variance on item #8, “Stood up for or helped other kids because of your size,” while the other participants endorsed some variance on this item. On the other hand, J.M., L.H., and S.M. indicated no impairment on item #19, “Got upset at mealtimes,” whereas D.U. reported different levels of impairment on this item throughout the intervention. Dynamic P-Technique allows for such differences in variance between individuals at the item level. However, certain items of HRQOL are less suited for analyses of individual variance, especially those that are unlikely to produce high levels of variance over the course of an intervention. Items without opportunity for daily fluctuation should not be included in tests of daily variability.

Third, some individual items may change on a more frequent basis, but their change is not reflected within the overall factor structure of HRQOL or its specific subscales. Since structural equation models are partially evaluated on the degree to which common-factor items share variance, Dynamic P-Technique models are strongly influenced by the shared variance of the indicators. When individual items vary independently of other items on that factor, these changes are lost because the indicators do not share this variance. Unfortunately, in P-technique factor analysis, when changes at the indicator level are not captured in the latent space, these fluctuations simply translate to poor model fit, instead of meaningful variance.

Overall, although HRQOL Emotional and Positive Social Attributes factors fit the structural models across individuals, HRQOL as a whole did not perform well for any participant. Instead, constructs which are more amenable to change and more likely to demonstrate daily variability are indicated for Dynamic P-Technique. Some evidence exists that mood states may vary on a daily basis (Axelson et al., 2003), and investigations into the complex interactions between physical activity and mood states are emerging in the pediatric literature. Utilizing time-dependent ratings of mood and physical activity across 119 individuals, Dunton and colleagues (2013) found that positive and negative affect are related to physical activity among youth. In fact, higher rates of positive affect resulted in increased physical activity 30 minutes later, which was followed by elevated ratings of positive affect shortly thereafter. As such, mood states such as positive affect and negative affect may be more appropriate for future small-N studies utilizing multiple observations from an individual.

Because of the ability for mood states to vary over time, it may not be surprising then that the factors of HRQOL that emerged as valid constructs in the current study were those most similar to mood states. Emotional HRQOL and Positive Attributes HRQOL may be capturing underlying mood states that are influenced by body size. For example, “I am sad/mad/frustrated/worried because of my size,” may, in fact, be conceptualized as the negative mood state associated with body dissatisfaction for overweight/obese youth. Future studies may also investigate the relations between Emotional HRQOL and Positive Attributes HRQOL, and more general constructs such as negative affect positive affect, and body dissatisfaction. It may be helpful to better understand conceptual differences or similarities between HRQOL and other associated constructs of psychological functioning.

Limitations

Although Dynamic P-Technique may be useful for understanding dynamic processes at the individual level, this study is not without limitations. First, readers are not advised to apply results of P-technique studies to all individuals, since the idiographic nature of this technique does not necessarily imply generalizable results. Instead, readers are encouraged to interpret Dynamic P-Technique studies as a preliminary step toward investigating intra-individual change processes that may occur at a group-level. As noted by Nelson, Aylward, and Rausch (2011), small-N studies offer a statistically rigorous option for investigating processes that require intensive data collection or may be high-risk if first evaluated on a large scale. Therefore, Dynamic P-Technique models are intended to capture unique changes at the individual level that could inform large-N designs to replicate results.

Second, while objective methods such as accelerometry (i.e., Actigraphy) can provide more valid estimates of physical activity levels than self-report methods (Janz, Witt, & Mahoney, 1995), they are only useful when worn by the participant. One participant noted that she enjoyed swimming on a regular basis; however, the device utilized (ActiGraph GT3X) is not designed for underwater use, and therefore did not capture that physical activity.

A third limitation of the methodology of Dynamic P-Technique relates to the burden of data collection and the likelihood of missing data. Because participants are asked to complete data collection outside the therapy setting, the potential for increased missing data is amplified. Although three daily timers were set on iPod Touch devices to remind participants to complete daily survey, a large amount of data were missing (HRQOL and VPA). While the modern missing data analytic techniques used for these analyses produced more valid results than if traditional approaches such as list-wise deletion, mean substitution, and regression imputation had been used (Little et al., 2013), original data remains the most valid representation of participant behavior. More frequent incentives may have increased participant's response rate (i.e., reward following each day of Actigraph wear or survey completion), as opposed to rewards delivered every two weeks. Also, as proposed by Nelson, Aylward, and Rausch (2011), Dynamic P-Technique may be useful in settings with natural opportunities for collection data (e.g., hospitals) such as blood glucose monitoring, sleep times, or nutrition.

Finally, because Dynamic P-Technique is indicated for frequently changing constructs, the study suffered from the relatively poor variance from HRQOL. Specifically, some items were invariant across the intervention, other items were inappropriate for daily collection and were eliminated, and additional items were variant independent of their respective factors of HRQOL. Future studies are likely more appropriate for children with less stable HRQOL, mood states, or other psychological constructs. Although the literature suggests that overweight and obese children present with impaired HRQOL, the current study may have benefited from additional inclusion criteria that established Clinical or Borderline-Clinical levels of HRQOL among the participants.

Conclusions

Even with the aforementioned limitations, this study is one of the first of its kind to intensively investigate the relations between physical activity and psychological states among adolescents at the intra-individual level. The novelty of this study's design and results is important, because as noted by Molenaar and Campbell (2009), applying group-level findings (i.e., pooling subjects) to the individual is indicated only when two strict and rare conditions are met. Only when the features of the model are identical for each individual (i.e., the items measuring a construct perform the same way for every person; "homogeneity"), and when the data are invariant across time (i.e., the means and variances do not change over time; "stationarity"), should group-level findings be applied to the individual. As demonstrated in this study, the participants were not homogeneous in their ratings of HRQOL, and the Emotional and Positive Attributes factors of HRQOL were not stationary over time (i.e., variance greater than 0). By furthering the scientific investigation of intra-individual change, this study responds to the plea of Molenaar (2004), who claimed "scientific psychology can only be complete if it includes the idiographic point of view, alongside the nomothetic point of view" (p. 216).

As demonstrated by the autoregressive HRQOL relationships from two participants, changes in HRQOL may follow a stable pattern of change, such that changes are gradual and incremental, but not highly variable day-to-day. Incremental changes in HRQOL may be the result of the cumulative effects of treatment components (e.g., physical activity or diet changes) or other psychosocial changes (e.g., self efficacy or social support). Clinically, emphasizing the importance of *consistent* adherence to treatment may work well with individuals with sufficient levels of motivation. For those individuals demonstrating incremental changes in HRQOL, tracking weekly or monthly changes in targeted components and constructs may better capture significant changes and salient relationships.

Encouragingly, one participant also evidenced daily interactions between HRQOL and VPA with significant within-lag relationships, such that higher levels of VPA had a beneficial effect on Positive Attributes HRQOL during the same day. While premature, this result potentially suggests that some individuals may receive immediate benefits from physical activity (potentially the same day). As opposed to long-term benefits (i.e., weight loss, increased cardiovascular health) that require acceptance of delayed gratification, evidence of daily benefits may be encouraging for those individuals with low motivation or poor ability to overcome barriers (e.g., low self efficacy or hope).

Although the hypotheses for dynamic relations between VPA and HRQOL were not supported, the study calls attention to the necessity for capturing *intra*-individual variation, especially among participants who are likely experiencing developmental changes (i.e., children and adolescents). Clinically, investigations of intra-individual change may be used to further understand behaviors that may be harmful to treatment progress or interfering with adherence to treatment. For instance, Dynamic P-Technique may be helpful for understanding the factors that predict lower positive affect, higher negative affect, or poor adherence to treatment (e.g., skipping therapeutic exercises or homework assignments), as a statistically rigorous option similar to functional behavior analysis utilized in clinical settings.

The results provide some insight into the ideographic nature of Emotional and Positive

Attributes HRQOL and VPA among four overweight and obese adolescents. These results clearly suggest that models among individuals are idiographic and future studies targeting frequently variable constructs (i.e., positive and negative affect) have the potential to capture meaningful dynamic processes. As clinicians and researchers of intervention studies are aware, a treatment component is only useful for a client or participant if it is effective for that individual. While Dynamic P-Technique sacrifices generalizability, it offers a rigorous methodological option for understanding the dynamic and nuanced change processes of that individual.

References

Adamo, K. B., Prince, S. A., Tricco, A. C., Connor-Gorber, S., & Tremblay, M. (2009). A comparison of indirect versus direct measures for assessing physical activity in the pediatric population: A systematic review. *International Journal of Pediatric Obesity, 4*, 2-27.

Ahn, S., & Fedewa, A. L. (2011). A meta-analysis of the relationship between children's physical activity and mental health. *Journal of Pediatric Psychology, 36*(4), 385-397.

Axelson, D. A., Bertocci, M. A., Lewin, D. S., Trubnick, L. S., Birmaher, B., Williamson, D. E., . . . Dahl, R. E. (2003). Measuring mood and complex behavior in natural environments: Use of ecological momentary assessment in pediatric affective disorder. *Journal of Child and Adolescent Psychopharmacology*, 13, 253–266.

Aylward, B. S., Anderson, R. A., & Nelson, T. D. (2010). Approaches to handling missing data within developmental and behavioral pediatric research. *Journal of Developmental & Behavioral Pediatrics*, *31*(1), 54-60.

Bize, R., Johnson, J. A., & Plotnikoff, R. C. (2007). Physical activity level and health-related quality of life in the general adult population: A systematic review. *Preventive Medicine*, *45*, 401-415.

Centers for Disease Control and Prevention. (2010). *State indicator report on physical activity, 2010.* Atlanta, GA: U.S. Department of Health and Human Services.

Corder, K., Ekelund, U., Steele, R. M., Wareham, N. J., & Brage, S. (2008). Assessment of physical activity in youth. *Journal of Applied Physiology*, *105*(3), 977-987.

Cushing, C. C., & Steele, R. G. (2012). Psychometric properties of *Sizing Me Up* in a community sample of 4th and 5th grade students with overweight and obesity. *Journal of Pediatric*

Psychology, 37(9), 1012-1022.

Daniels, S. R. (2006). The consequences of childhood overweight and obesity. *The Future of Children, 16*(1), 47-67.

Daniels, S. R., Arnett, D. K., Eckel, R. H., Gidding, S. S., Hayman, L. L., Kumanyika S., … Williams, C. L. (2005). Overweight in children and adolescents: Pathophysiology, consequences, prevention, and treatment. *Circulation, 111*, 1999-2012.

Davis, A. M., Daldalian, M. C., Mayfield, C. A., Dean, K., Black, W. R., Sampilo, M. L., ... & Suminski, R. (2013). Outcomes from an Urban Pediatric Obesity Program Targeting Minority Youth: The Healthy Hawks Program.*Childhood Obesity*.

DiLorenzo, T. M., Stucky-Ropp, R. C., Vander Wal, J. S., & Gotham, H. J. (1998). Determinants of exercise among children II: A longitudinal analysis. *Preventive Medicine*, *27*, 470-477.

Dinas, P. C., Koutedakis, Y., & Flouris, A. D. (2011). Effects of exercise and physical activity on depression. *Irish Journal of Medical Science*, 180, 319-325.

Dionne, I., Almeras, N., Bouchard, C., & Tremblay, A. (2000). The association between vigorous physical activities and fat deposition in male adolescents. *Medicine & Science in Sports & Exercise*, *32(*2), 392-395.

Dunton, G. F., Huh, J., Leventhal, A. M., Riggs, N., Hedeker, D., Spruijt-Metz, D., & Pentz, M. A. (2013). Momentary Assessment of Affect, Physical Feeling States, and Physical Activity in Children. *Health Psychology*. Advance online publication.

Ekelund, U., Aman, J., Yngve, A., Renman, C., Westerterp, K., & Sjostrom, M. (2002). Physical activity but not energy expenditure is reduced in obese adolescents: A case-control study. *American Journal of Clinical Nutrition, 76*, 935-941.

Enders, C. K. (2010). *Applied missing data analysis*. New York, New York: The Guilford Press.

Engle, R., & Watson, M. (1981). A one-factor multivariate time series model of metropolitan wage rates. *Journal of the American Statistical Association, 76*(376), 774-781.

Goran, M. I., & Treuth, M. S. (2001). Energy expenditure, physical activity, and obesity in children. *Pediatric Clinics of North America, 48*(4), 931-953.

Griffiths, L. J., Parsons, T. J., & Hill, A. J. (2010). Self-esteem and quality of life in obese children and adolescents: A systematic review. *International Journal of Pediatric Obesity, 5*(4), 282-304.

Holt, N. L., Kingsley, B. C., Tink, L. N., & Scherer, J. (2011). Benefits and challenges associated with sport participation by children and parents from low-income families. *Psychology of Sport and Exercise*, *12*(5), 490-499.

Janssen, I., & LeBlanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity, 7*(40), 1-16.

Janz, K. F., Witt, J., Mahoney, L. T. (1995). The stability of children's physical activity as measured by accelerometry and self-report. *Medicine & Science in Sports & Exercise*, 27(9), 1326-1332.

Jelalian, E., & Hart, C. N. (2009). Pediatric obesity. In M. C. Roberts & R. G. Steele (Eds.), *Handbook of pediatric psychology, fourth edition* (pp. 446-463). New York: The Guilford Press.

Kahn, J. A., Huang, B., Gillman, M. W., Field, A. E., Austin, S. B., Colditz, G. A., & Frazier, A. L. (2008). Patterns and determinants of physical activity in US adolescents. *Journal of Adolescent Health*, *42*(4), 369-377.

Kimm, S. Y. S., Glynn, N. W., Kriska, A. M., Barton, B. A., Kronsberg, S. S., Daniels, S. R., …

Liu, K. (2002). Decline in physical activity in black girls and white girls during adolescence. *The New England Journal of Medicine, 347*(10), 709-715.

Larun, L., Nordheim, L. V., Ekeland, E., Hagen, K. B., & Heian, F. (2006). Exercise in prevention and treatment of anxiety and depression among children and young people. *Cochrane Database of Systematic Reviews, 3*, 1-47.

Lee, I. A., & Little, T. D. (2012). P-Technique factor analysis. In B. Laursen, T. D. Little, & N. A. Card (Eds.), *Handbook of developmental research methods* (pp. 350-363). New York, NY: The Guilford Press.

Little, T. D. (2013). *Longitudinal structural equation modeling*. New York, New York: The Guilford Press.

Little, T. D., Bovaird, J. A., & Slegers, D. W. (2006). Methods for the analysis of change. In D. K. Mroczek, & T. D. Little (Eds.), *Handbook of personality development* (pp. 181–211). Mahwah, NJ: Erlbaum.

Masse, L. C., Fuemmeler, B. F., Anderson, C. B., Matthews, C. E., Trost, S. G., Catellier, D. J., & Treuth, M. (2005). Accelerometer data reduction: a comparison of four reduction algorithms on select outcome variables. *Medicine and Science in Sports and Exercise, 37*(11), 544.

Molenaar, P. C. (2004). A manifesto on psychology as idiographic science: Bringing the person back into scientific psychology, this time forever. *Measurement, 2*(4), 201-218.

Molenaar, P. C., & Campbell, C. G. (2009). The new person-specific paradigm in psychology. *Current Directions in Psychological Science, 18*(2), 112-117.

Nelson, T. D., Aylward, B. S., & Rausch, J. R. (2011). Dynamic P-Technique for modeling patterns of data: Applications to pediatric psychology research. *Journal of Pediatric*

Psychology, 36(9), 959-968.

Ogden, C. L., Carroll, M. D., Kit, B. K., & Felgal, K. M. (2012). Prevalence of obesity and trends in body mass index among U.S. children and adolescents, 1999-2010. *Journal of the American Medical Association, 30*7(5), 483-490.

Parfitt, G., Pavey, T., & Rowlands, A. V. (2009). Children's physical activity and psychological health: The relevance of intensity. *Acta Pediatrica, 98*, 1037-1043.

Penedo, F. J., & Dahn, J. R. (2005). Exercise and well-being: A review of mental and physical health benefits associated with physical activity. *Current Opinion in Psychiatry, 18*, 189-193.

Prasad, A., St-Hilaire, S., Wong, M. W., Peterson T., & Loftin, J. (2009). Physical activity and depressive symptoms in rural adolescents. *North American Journal of Psychology, 11*(1), 173-188.

Purslow, L. R., Hill, C., Saxton, J., Corder, K., & Wardle, J. (2008). International Journal of Behavioral Nutrition and Physical Activity. *International Journal of Behavioral Nutrition and Physical Activity, 67*(5).

Sallis, J. F., Prochaska, J. J., & Taylor, W. C. (2000). A review of the correlates of physical activity of children and adolescents. *Medicine & Science in Sports & Exercise, 32*(5), 963-975.

Schwimmer, J. B., Burwinkle, T. M., & Varni, J. W. (2003). Health related quality of life of severely obese children and adolescents. *Journal of the American Medical Association, 289*(14), 1813-1819.

Shoup, J. A., Gattshall, M., Dandamundi, P., & Estabrooks, P. (2008). Physical activity, quality of life, and weight status in overweight children. *Quality of Life Research, 17*(3), 407-

412.

Sirard, J. R., Melanson, E., Li, L., & Freedson, P. (2000). Field evaluation of the Computer Science and Applications, Inc. physical activity monitor. *Medicine & Science in Sports & Exercise*, 32(3), 695-700.

Speiser, P. W., Rudolf, M. C. J., Anhalt, H., Camacho-Hubner, C., Chiarelli, F., Eliakim, A., … Hochberg, Z. (2005). Consensus statement: Childhood obesity. *Journal of Clinical Endocrinology and Metabolism, 90*(3), 1871-1887.

Steele, R. G., Aylward, B. S., Jensen, C. D., Cushing, C. C., Davis, A. M., & Bovaird, J. A. (2012). Comparison of a family-based group intervention for youths with obesity to a brief individual family intervention: A practical clinical trial of *Positively Fit*. *Journal of Pediatric Psychology*, *37*(1), 53-63.

Steele, R. G. and the Pediatric Health Promotion and Maintenance Lab. (n.d.). Therapist manual for *Positively Fit*: A family-based group intervention for child and adolescent weight management. Unpublished manuscript: University of Kansas.

Strauss, R. S., Rodzilsky, D., Burack, G., & Colin, M. (2001). Psychosocial correlates of physical activity in healthy children. *Archives of Pediatrics & Adolescent Medicine*, *155*(8), 897.

Telama, R., Yang, X., Viikari, J., Valimaki, I., Wanne, O., & Raitakari, O. (2005). Physical activity from childhood to adulthood: A 21-year tracking study. *American Journal of Preventive Medicine*, *28*(3), 267-273.

Tremblay, M. S., Inman, J. W., & Willms, J. D. (2000). The relationship between physical activity, self-esteem, and academic achievement in 12-year-old children. *Pediatric exercise science*, *12*(3), 312-323.

Troiano, R., Berrigan, D., Dodd, K. W., Masse, L. C., Tilert, T., & McDowell, M. (2007). Physical activity in the United States measured by accelerometer. *Medicine & Science in Sports & Exercise, 40*(1), 181-188.

van der Horst, K., Paw, M. J. C. A., Twisk, J. W. R., & van Mechelen, W. (2007). A brief review on correlates of physical activity and sedentariness in youth. *Medicine & Science in Sports & Exercise, 39*(8), 1241-1250.

Varni, J. W., Seid, M., & Kurtin, P. S. (2001). PedsQL 4.0: Reliability and validity of the Pediatric Quality of Life Inventory Version 4.0 Generic Core Scales in healthy and patient populations. *Medical Care, 39*(8), 800-812.

Vinney, L. A., Grade, J. D., & Connor, N. P. (2011). Feasibility of using a hnandheld electronic device for the collection of patient reported outcomes data from children. *Journal of Communication Disorders, 45*, 12-19.

Vuillemin, A., Boini, S., Bertrais, S., Tessier, S., Oppert, J.-M., Hercberg, S., … Briancon, S. (2005). Leisure time physical activity and health-related quality of life. *Preventive Medicine, 41,* 562-569.

Williams, J., Wake, M., Hesketh, K., Maher, E., & Waters, E. (2005). Health-related quality of life of overweight and obese children. *Journal of the American Medical Association, 293*(1), 70-76.

Zeller, M. H., & Modi, A. C. (2009). Development and initial validation of an obesity-specific quality-of-life measure for children: *Sizing Me Up. Obesity, 17*, 1171-1177.

Appendix

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	SD	Variance
J. M. (Participant 1)							
Vigorous Physical Activity (Minutes)	46	8.50	0.17	8.67	2.56	2.09	4.37
Emotional HRQOL	41	33.33	66.67	100.00	94.72	11.60	134.57
Teasing HRQOL	41	33.33	66.67	100.00	94.31	11.55	133.47
Positive Attributes HRQOL	41	26.67	66.67	93.33	86.50	9.13	83.31
Physical HRQOL	41	33.33	66.67	100.00	91.46	13.37	178.78
D. U. (Participant 2)							
Vigorous Physical Activity (Minutes)	31	19.83	0.33	20.17	6.66	5.25	27.54
Emotional HRQOL	32	40.00	20.00	60.00	37.29	12.19	148.70
Teasing HRQOL	32	83.33	16.67	100.00	75.52	15.83	250.62
Positive Attributes HRQOL	32	75.00	25.00	100.00	88.80	17.53	307.39
Physical HRQOL	32	50.00	50.00	100.00	92.19	13.38	178.93
L. H. (Participant 3)							
Vigorous Physical Activity (Minutes)	42	73.67	0.33	74.00	9.44	14.73	217.03
Emotional HRQOL	42	53.33	20.00	73.33	37.30	13.50	182.24
Teasing HRQOL	42	75.00	25.00	100.00	73.81	20.71	428.77
Positive Attributes HRQOL	42	75.00	0.00	75.00	39.48	24.49	599.80
Physical HRQOL	42	33.33	66.67	100.00	97.22	8.16	66.62
S. M. (Participant 4)							
Vigorous Physical Activity (Minutes)	28	24.33	0.00	24.33	3.67	5.60	31.31
Emotional HRQOL	39	53.33	26.67	80.00	49.23	15.87	251.73
Teasing HRQOL	39	25.00	75.00	100.00	83.97	9.82	96.43
Positive Attributes HRQOL	39	33.33	66.67	100.00	90.38	7.77	60.45
Physical HRQOL	39	0.00	100.00	100.00	100.00	0.00	0.00

N represents the number of recorded observations. Vigorous Physical Activity is represented by number of minutes per day. Emotional, Teasing, Positive Attributes, and Physical HRQOL subscale scores are scored on a scale of 0-100, with 100 indicating no impairment, and 0 indicating maximum impairment. *Sizing Me Up* subscales are scored with all items included except those without ability for daily fluctuation (items 11, 12, 14, 18, and 22). Items with zero variance are included in descriptive statistics. The Social Avoidance subscale of HRQOL is not included due to insufficient number of items remaining for valid score calculations.