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Relations Between Anhedonia and Physical Activity

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Abstract

Objective—To examine the relation of 2 measures of anhedonia—a specific facet of depression indicative of inability to experience pleasure—to physical activity (PA).

Method—Cross-sectional correlational survey study of 157 college students (73% female, M age 19.9 years).

Results—One or both measures of anhedonia were inversely associated with walking frequency, moderate-intensity PA frequency and duration, and vigorous-intensity PA frequency and duration (βs −16 to −.27, Ps < .05). Some of these associations were statistically mediated by lower PA enjoyment.

Conclusions—Deficient pleasure may be an important affective mechanism underlying PA behavior.

Keywords

anhedonia; physical activity; depressive symptoms; exercise

There is an extensive body of literature documenting an inverse association between level of depressive symptoms and physical activity (PA). Although some investigations have not found evidence of this association,[1] results from observational studies are typically consistent with a multidirectional relationship between depressive symptoms and PA.[2,3] That is, higher level of depressive symptoms prospectively predicts lower PA over time,[2,3] lower PA increases risk of future depressive symptoms,[2–7] and depression and low PA are concurrently associated with one another.[5,8] This association exists over and above other potentially confounding factors[2,3] and appears to extend across (1) subclinical depressive symptoms and major depression;[3] (2) various levels of PA frequency, intensity, and duration;[9] and (3) a variety of different age-groups.[2,3,10]

Despite consistent evidence that the association between depressive symptoms and lower PA exists, the mechanisms underlying this relation are not entirely clear. This is an important gap in the literature because clarification of the nature and mechanisms of the depression-PA association could advance theoretical models of health behavior and shed light on intervention targets for people with emotional disturbance who are not physically active.[7]

The heterogeneity of depressive symptoms may be an important barrier that has often been overlooked in prior PA research. Most extant studies regard depression as a unitary homogenous phenotype that can be identified by computing the combined overall severity across all depressive symptoms. However, depression may be more accurately characterized

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as a complex set of numerous intermediate phenotypes that only loosely cluster together with one another.[11] It has therefore been proposed that by partitioning depression into more narrow classifications based on key individual features (eg, depressed mood, anhedonia, appetite changes, psychomotor disturbance, stress sensitivity), phenotypic markers representing more direct expressions of underlying mechanisms might be isolated.[11] Indeed, different symptoms in depression may have unique psychosocial and biological determinants.[12,13] Therefore, investigating the role of intermediate depressive phenotypes in PA may yield more meaningful insights into the relation between depressive symptoms and low PA.

Anhedonia—the inability to experience pleasure in response to rewarding stimuli—is a unique depressive phenotype[11] that may be useful for PA research. Though levels of anhedonia can fluctuate over time in some circumstances (eg, onset to offset of depressive episodes), anhedonia is typically stable.[18] Anhedonia lies on a continuum; varies widely in the population; is psychometrically distinct from other constructs such as affective flattening, sadness, and amotivation; and is unique from but correlated with level of overall depressive symptomatology.[18–20] Anhedonia's neuropathology putatively involves attenuated mesolimbic and nigrostriatal activity and reduced sensitivity to the effects of nondrug rewards on phasic mesolimbic dopamine release.[21,22] Of note, anhedonia associates with increased risk of cardiac events,[14,15] cigarette smoking,[16] and illicit drug use.[17] Given its role in heart disease and health behaviors, anhedonia may also relate with PA.

Anhedonia may be inversely associated PA for several reasons. PA has been shown to acutely enhance dopaminergic activity within the striatum.[23,24] Given that treatments which enhance dopamine raise responsiveness to rewards,[25,26] it is possible that PA may acutely counteract anhedonia. It is also possible that anhedonia may diminish motivation to engage in PA. Because people with high anhedonia experience deficient levels of pleasure from most nonpharmacological rewards,[27] they may find PA to be less pleasurable, which could in turn reduce desire to engage in PA.[28] Thus, the inverse relation between anhedonia and PA may be mediated by lower levels of PA's subjective rewarding effects. However, to our knowledge, there are no extant studies on the relation between anhedonia and PA in humans.

This article reports results from a preliminary investigation of the association between anhedonia and PA using a cross-sectional correlational design in a sample of college students. Using this sample allows us to understand the link between anhedonia and PA during a high-risk period for affective turmoil, as age of first depressive episode for many individuals occurs during young adulthood.[29] Furthermore, young adulthood is typically a period in which PA declines.[30] In addition, we examine several PA outcomes (eg, frequency, duration, intensity) separate from one another in this initial study, given that the relation between mood disturbance and PA may vary across different doses of PA.[9] The primary aims were: (1) to examine the relation between anhedonia and frequency, duration, and intensity of PA; and (2) to investigate whether the subjective rewarding effects of PA mediate the relationship between anhedonia and low PA.

METHODS

Participants

Participants were 157 undergraduate and graduate students enrolled at a medium-sized university in the western United States. Fliers, class announcements, and electronic postings announcing the opportunity to participate in a survey study of emotion, genes, and health in university students were used to recruit participants. The inclusion criteria were (1) 18 years of age or older, (2) able to provide informed consent, and (3) currently enrolled at the

university. Participants received extra credit for a course they were taking for completing the study. The university's institutional review board approved the study.

Procedure

Study announcements encouraged participants to either correspond with research staff to obtain additional information about the study or directly sign up for a data collection session via a Web-based student research participation interface. At each in-person 90- to 180-minute data collection session, participants first were explained the study procedures and completed informed consent (no individuals decided not to participate in the study after the informed consent procedures were explained). Then participants completed the study protocol, which involved filling out surveys assessing demographics, affective characteristics, and health behaviors and providing a saliva sample for genetic analysis (genetic data not yet available). Data collections took place on weekdays and involved groups of 2 to 25 participants per session.

Affect Measures

Snaith Hamilton Pleasure Scale (SHAPS).[31]—The SHAPS is a 14-item questionnaire that measures capacity to experience pleasure in the past few days. Participants agree/disagree to statements of pleasure response to typically pleasant experiences (see Table 1 for a list of items). Each of the items has a set of 4 response categories: Definitely Agree (= 0), Agree (= 1), Disagree (= 2), and Definitely Disagree (= 3). In the original scoring algorithm, Snaith et al [31] proposed to recode each item as dichotomous (Definitely Agree or Agree = 0; Disagree or Definitely Disagree = 1). An updated scoring algorithm with better psychometric properties codes each of the 4 response categories separately (ranging 0–3) in order to generate greater dispersion of the data and is now more commonly used.[19,32] In the present study, the original scoring was used only to categorize the proportion of participants diagnosed as anhedonic based on Snaith et al's recommended cutoff (original SHAPS score > 2).[31] For all other analyses, the updated scoring algorithm that sums scores across 4 response categories was used (Cronbach α = .85).

Tripartite Pleasure Inventory (TPI).[33]—The TPI is a self-report measure of trait anhedonia for which respondents rate 12 common types of pleasant experiences (see items in Table 1). For the Responsivity (TPI-R) subscale, participants rate the degree of pleasure/happiness/enjoyment they usually feel from each experience (4 = No Pleasure, 3 = Mild Pleasure, 2 = Moderate Pleasure, 1 = Great Pleasure, 0 = Extreme Pleasure). A mean score across the 12 items is calculated. However, because 2 of the items are related to PA, they were not included in the TPI-R score in order to avoid criterion contamination, yielding a 10-item composite. Although the psychometric properties of the TPI-R have not yet been published, in this sample the 10-item TPI-R had adequate internal consistency (α = .77) and convergent validity with the SHAPS (r = .44, P < .0001). The TPI-R is important to include in addition to the SHAPS because (1) its items are updated to include recent societal trends (eg, socializing…over the Internet), which are not captured by the SHAPS that was developed in 1995; and (2) it assesses trait-level anhedonia, whereas the SHAPS assess anhedonia levels in the past few days.

Center for Epidemiologic Studies Depression (CESD).[34]—The CESD was used to assess depressive symptom severity and has excellent psychometric properties in general population samples (α in this sample = .90).

PA Measures

Physical Activity Enjoyment Scale (PAES)[28]—The PAES includes statements indicative of particular affective responses of PA rated on a Likert scale, which has a left anchor at 1 = disagree a lot to a right anchor at 5 = agree a lot. Responses 2, 3, and 4 on the Likert scale are unlabeled and are used to denote intermediate responses between the left and right anchors. For the PAES trait-version, the stem used to cue responses for each item is "When I am physically active or exercising…" so as to measure one's typical affective responses to PA.[35] The measure includes 8 items indicative of rewarding effects: "I enjoy it"; "I find it pleasurable"; "It gives me energy"; "It's very pleasant"; "My body feels good"; "I get something out of it"; "It's very exciting"; "It gives me a strong feeling of success." Six items are indicative of aversive effects: "I feel bored"; "I dislike it"; "It's no fun at all"; "It makes me depressed"; "It frustrates me"; "It's not at all interesting." Following prior data and theory,[36,37] separate subscales based on mean response per item were computed for rewarding effects (α = .89), aversive effects (α = .85), and a combined overall composite scale in which aversive items were reversed scored and rewarding items were positively scored (α = .92), although see Dunton et al.[38] The rewarding and aversive effects subscales exhibited 53% overlapping variance suggesting that they were assessing related but not entirely redundant constructs. These scales have evidenced good psychometric properties and associate with objective physical activity indicators.[28,35–37] Given that anhedonia is associated more strongly with positive affect and pleasure than with negative affect[39] and because the hypotheses were focused on pleasure gained from PA, the primary measure analyzed from the PAES was the rewarding effects subscale.

International Physical Activity Questionnaire—Short Form (IPAQ).[40]—The IPAQ is a widely used measure of PA that asks questions regarding frequency and duration of PA during a usual week for 3 levels of intensity: (1) walking; (2) moderate PA; and (3) vigorous PA. For each type of intensity, 3 quantitative indexes are produced: (1) frequency (days per week), (2) duration (duration of PA on days when engaged in PA of that type), and (3) total time per week (frequency × duration). Given that this was the first study of anhedonia and PA, all IPAQ indexes were analyzed separately so as to not overlook potential associations of anhedonia to one aspect of PA but not another that could be lost when focusing on only composite outcomes. (Also, Table 2 illustrates that the individual indexes were only moderately correlated in many cases, suggesting that they tap distinct processes.) The IPAQ has comparable validation properties relative to other self-report PA instruments, when tested against objective measures of PA.[40–45] Intercorrelation of items on the IPAQ can be found in Table 2. Though the standard IPAQ asks participants to report PA during the preceding week up until the assessment, [40] the instructions were modified so as to assess PA during a usual week, given that this study was interested in making generalizations to participants' typical levels of PA rather solely than their recent PA.

Additional Measures

Demographics and smoking history ("Have you smoked more than 100 cigarettes in your lifetime?" yes/no) were assessed with author-constructed questionnaires. Body mass index (BMI) was computed based on self-reported height and weight. Severity of drug and alcohol use behavior was assessed with the widely used and well-validated Alcohol Use Disorders Identification Test (AUDIT)[46] and Drug Abuse Screening Test (DAST),[47] respectively.

Data Analysis

Following calculation of descriptive statistics, all variables were checked for normality, and transformations to approximate normality were applied when appropriate. One of the possible responses on IPAQ items is "Don't know/Not Sure." In such cases, the data were

coded as missing and pairwise deletion was applied, resulting in sample sizes ranging from 129 to 157 across analyses.

Preliminary analyses examined correlations among the anhedonia scales and clinical and demographic variables as well as among the PA-related variables. The primary analyses had 2 aims: (1) to examine relations between anhedonia and PA frequency and duration indexes and (2) to explore if these relations were statistically mediated by rewarding effects of PA. For the first aim, linear regression models were used to test relations of between anhedonia and each PA outcome (walking frequency, duration/day, total duration/week; moderate PA frequency, duration/day, total duration/week; vigorous PA frequency, duration/day, total duration/week). For aim 2, mediational pathways were tested for only the particular anhedonia-PA associations that were significant. Mediational paths were analyzed by computing the product of the coefficients[48] from 2 regression models, (1) one examining relation between the predictor (anhedonia) and the mediator (PAES-Reward scale) and (2) one examining the relation the mediator (PAES rewarding scale) and the outcome (IPAQ variable). The product of coefficients served as the indicator of the strength of the indirect (mediational) effect, for which significance was determined using the PRODCLIN approach involving estimating asymmetric confidence intervals around the mediational effect.[48] We conclude that the mediational effect is significant if the confidence intervals around indirect effect do not include zero. The relation between anhedonia and the IPAQ outcome after adjusting for the PAES-Reward Scale indicated the remaining direct effect, which reflects the extent of anhedonia's relation to PA that is not channeled through affective response to PA. Separate sets of models were tested for each outcome, and each model was tested twice —once using SHAPS score as the predictor and once substituting the TPI-R score as the predictor. Each model was tested with and without adjusting for gender and CESD score, which were the only other study variables significantly associated with anhedonia.

Because there is some evidence of gender differences in the PA-depression association,[6] exploratory analyses paralleling the models described above examined whether gender moderated the relationship between anhedonia and PA indexes. For comparative purposes, we also ran parallel models examining the relation of CESD scores to IPAQ measures and PAES scales.

Primary results are reported as standardized beta-weights (βs). Significance was set at $P < .05$ (2-tailed) without any alpha-correction, so as to not overlook any potential associations in this first-ever study of the relation between anhedonia and PA.

RESULTS

Sample Characteristics

Demographic and health indicators—Of the 157 participants, 73% were female and the average age was 19.9 (SD = 1.8). Fourteen percent self-identified as His-panic; and the racial breakdown was as follows: 35% Asian, 3% black, 10% multi-racial, 7% Middle Eastern, 5% Non-black Hispanic, and 40% white. The average BMI was 21.8 (SD = 2.8), with 10% being classified as underweight (BMI < 18.5), 79% normal weight (18.5 – 25), 12% overweight (25 – 30), and 1% obese (>30). The mean scores on the DAST and AUDIT were 4.6 (SD = 2.1) and 5.3 (SD = 5.1), respectively, suggesting a relatively low level of average substance use problems; and 12% of participants were lifetime cigarette smokers. Anhedonia was not significantly associated with any of the aforementioned characteristics, with the exception of men reporting higher anhedonia than did women on the SHAPS ($r = .17$ $P = .04$) but not on the TPI-R ($r = .13$, $P = .11$).

Affect—The average SHAPS score was 8.82 (SD = 5.46, range 0 – 29), and 18% of the sample scored above the cutoff for clinically significant anhedonia. On the TPI-R, mean scores were 1.14 (SD = 0.50, range 0.10 –2.79). The average CESD score was 14.6 (SD = 9.6); and following suggested cutoffs,[47] 66% of the sample scored below the cutoff for mild depression (<16), 17% had mild depressive symptoms (16–26), and 16% had moderate to severe symptoms (>26). Scores on the SHAPS and CESD were significantly correlated (r= . 24, P = .003), whereas the relation of TPI and CESD was nonsignificant (r = .14, P = .07).

Physical activity—As noted in Table 2, the SDs indicate considerable variability in PA behaviors and affective response to PA in the sample. The pattern of correlations among different PA variables yielded from the IPAQ was moderate in many cases suggesting adequate discriminability across variables, especially when comparing indexes across varying levels of PA intensity (Table 2). Seventy-eight percent of the sample met federal recommendations for weekly PA (ie, ≥ 150 min/week of moderate-intensity PA, ≥ 75 min/ week week of vigorous-intensity PA, or a combination of moderate and vigorous PA totaling at least 150 min/week).

Interrelations Between Anhedonia, Affective Responses to PA, and PA Frequency and Duration

Given that the only characteristics that were significantly associated with anhedonia were gender and CESD score, these served as the only covariates included in adjusted models.

Anhedonia and PA behaviors—As noted in the left-hand portion of Table 3, higher anhedonia on the SHAPS was significantly associated with lower walking frequency, lower moderate PA frequency, lower duration of moderate PA on active days, and lower time spent engaging in moderate PA over the entire week. These relations remained significant after controlling for gender and level of depressive symptoms, with the exception of the relation of anhedonia to minutes engaged in moderate PA per day, which was reduced to nonsignificant in the adjusted model (P = .07).

Anhedonia on the TPI-R was significantly with lower PA on all IPAQ indexes, except for walking duration per day and week (left-hand portion of Table 4).

Mediational Pathway Involving Anhedonia → Rewarding Effects of PA → PA Indexes

Mediational analyses were performed for only PA indexes that were significantly associated with anhedonia.

SHAPS—A significant indirect (mediational) effect was found, such that lower rewarding effects of PA mediated the effect of anhedonia on lower walking frequency (right-hand portion of Table 3). The remaining direct effect of anhedonia on lower walking frequency after adjusting for the PAES-Reward subscale was significant. Thus, PAES-Reward partially, but not fully, mediated the relation between SHAPS and lower walking frequency.

PAES-Reward did not mediate the associations between SHAPS and moderate-intensity PA indexes, as demonstrated by the nonsignificant indirect effects (right-hand portion of Table 3). Although the indirect effects were not statistically significant, we analyzed the remaining direct effect of SHAPS scores on moderate-intensity PA indexes after adjusting for PAES-Reward scores. These results illustrate that the remaining direct effects of SHAPS on moderate-intensity PA indexes were slightly reduced after adjusting for PAES-Reward scores (right-hand portion of Table 3).

TPI-R—There was a significant indirect (mediational) effect of anhedonia on lower walking frequency through PAES-Reward (right-hand portion of Table 4). The remaining direct effect of anhedonia on lower walking frequency after adjusting for PAES-Reward was not significant, suggesting that PAES-Reward fully mediated the association between TPI-R and lower walking frequency.

The relations of TPI-R to lower frequency and duration of moderate-intensity PA were not mediated by PAES-Reward as evidenced by the nonsignificant indirect effects (right-hand portion of Table 4). Indeed, the remaining direct effects of TPI-R on lower levels of moderate-intensity PA were not altered after statistically adjusting for PAES-Reward.

The effects of TPI-R on lower frequency and duration of vigorous-intensity PA were mediated by lower PAES-Reward as illustrated by the significant indirect effects (right-hand portion of Table 4). In each case, the remaining direct effects of TPI-R on indexes of vigorous-intensity PA were not significant after adjusting for PAES-Reward (right-hand portion of Table 4). Thus, PAES-Reward fully mediated the associations between TPI-R and lower frequency and duration of vigorous-intensity PA.

Moderation by Gender

To explore gender differences in the PA-depression association, linear regression models including anhedonia, gender, and the gender-by-anhedonia interaction term as predictors of PAES-Reward subscale and IPAQ indexes were tested. Models were calculated with and without adjusting for CESD score, and parallel models were tested for both the SHAPS and TPI-R. The gender-by-anhedonia interaction term was not significant in any model.

Relation of Depressive Symptoms to PA

For comparative purposes, we examined regression models examining the relation of CESD score to PA variables, which yielded no significant effects (βs ranging from .00 to −.15, Ps > .06).

Discussion

This cross-sectional study found that higher anhedonia was associated with lower levels of several PA indicators in college students. The strength of significant associations between anhedonia and PA was between a small and medium effect size (βs ranging from −.16 to −.27 across measures), which is similar to the effect sizes found for investigations of the relation between depression and PA.[4,9] The findings differed across different doses (frequency, duration, intensity) of PA. A recent review article summarizing the results of 67 empirical studies concluded that there was sufficient evidence that depressive symptoms are associated with varying levels of frequency, duration, and intensity.[9] However, results across the 67 studies were inconsistent with regard to whether lighter or more vigorous intensity of PA is more robustly associated with PA.[9] The authors suggested that individual differences may be important to explaining heterogeneity in the relation between affect and PA,[9] which has been suggested in other work.[49] The current findings indicate that anhedonia may be one such individual difference characteristic that may be particularly important for explaining variability in moderate and vigorous forms of PA.

The findings were only somewhat consistent across the 2 anhedonia measures. The major differences in findings were (1) strength of effects was generally more robust for the TPI-R than the SHAPS; and (2) anhedonia on the TPI-R, but not the SHAPS, was significantly associated with vigorous PA indexes. It is possible that the anhedonia construct tapped by the TPI-R may be more relevant to PA in college students than the corresponding construct

measured by the SHAPS is relevant to PA in college students. The TPI-R was recently developed and includes items that may be more representative of pleasant experiences commonly encountered in current young adults (eg, "socializing…over the Internet"), which could result greater construct validity relative to the SHAPS, which was developed in 1995.[31] Also, the items on the TPI-R include both high- and low-arousal pleasant experiences (eg, "romantic and sexual activities"), whereas the SHAPS primarily includes low-arousal experiences. Because vigorous PA is a high-arousal activity, it may be more relevant to the TPI-R, whereas walking and moderate PA may be relevant to both anhedonia measures. Lastly, the TPI-R measures trait anhedonia, whereas the SHAPS measures anhedonia in the past few days. Given that the IPAQ used in this study assessed PA in a usual week, the temporal overlap in assessment is more prominent for the TPI. Though outside the scope of the present study, one possibility that could be explored in future research is whether state anhedonia mediates the influence of trait anhedonia on PA. Individuals with an anhedonic personality may experience more frequent and extreme states of anhedonia, which may in turn reduce the frequency, duration, and intensity of PA over time. Given that the SHAPS and TPI were significantly associated in this study ($r = .44$, $P < .0001$), this is a plausible hypothesis. Regardless, these results provide stronger support for use of the TPI-R as compared to the SHAPS in future PA research.

Some of the associations between anhedonia and PA were mediated by affective response to PA, such that higher anhedonia was associated with diminished subjective rewarding effects of PA, which in turn were related to lower levels of PA. Perhaps, people with high trait anhedonia experience tend to experience less pleasure from PA (as they do with other reinforcing behaviors),[27] which subsequently diminishes motivation to engage in PA on a regular basis. Because the relation between anhedonia and vigorous-intensity PA was fully mediated by affective response to PA, subjective emotional experience during PA may be the primary mechanism linking anhedonia and lower vigorous PA. By contrast, the relation between anhedonia as measured by the SHAPS and lower walking frequency was only partially mediated by affective response to PA. Thus, emotional reaction to PA and other potential mechanisms may account for this relation. The relation between anhedonia and moderate PA, however, was not significantly mediated by affective response to PA, which suggests alternate mechanisms for this relation.

Due to the cross-sectional design, another account for the current findings is that engaging higher levels of PA could alleviate state anhedonia. Indeed, a recent preclinical study found that experimentally manipulated exercise reversed the effects of dexamethasone administration—a validated method for inducing depressive behavior—on anhedonic behavior in rats.[50] It is also possible that confounding factors account for the anhedonia-PA association presented in this study. Yet, this is unlikely, given that anhedonia was unrelated to other demographic and health characteristics (besides gender, which was adjusted for) and this relation was mediated by a theoretically relevant intermediate variable in some cases.

Because there is some evidence from general population samples that women may exhibit stronger relations between PA and depression than men do,[6] we conducted an exploratory analysis of whether gender moderated the relationship between anhedonia and PA. We did not find any evidence of gender differences. Given this finding coupled with results from a large-scale study of college students that did not find gender differences in PA-depression associations,[8] it is possible that population type and age may modify the effects of affect disturbance on PA. Also, the study sample size may not have been large enough to detect moderation effects.

Although the current findings are useful for understanding the overall relation between aspects of depression and PA, it is important to note that combined level of depressive

symptoms was not associated with level of PA. Though this result was unexpected, perhaps the sample was too small to detect depression-PA associations, yet large enough to detect a signal for anhedonia. Future studies using larger samples will be better positioned to answer questions regarding the relative effect sizes of anhedonia versus depression on PA.

This study's limitations should be taken into account when interpreting the findings. This preliminary investigation used a cross-sectional design and had a modest sample size. Though useful for generating hypotheses about the anhedonia-PA relationship that can be addressed in future large-scale longitudinal work, causal interpretations of the current data are precluded. Furthermore, precise estimates of the strength of the anhedonia-PA relationship cannot be obtained on the basis of these data, though most results suggested a small- to medium-sized effect. Only self-report measures were included. Although the IPAQ has reasonable validity in comparison to other survey-based PA measures,[40–45] future work should examine if anhedonia-PA relations are detected using objective measures of these constructs.[51,52] In addition, this study used a modified version of the IPAQ that assessed PA during a usual week, which differs from the standard IPAQ format that assesses PA over the past week leading up to the assessment.[40] Thus, previous estimates of the psychometric properties of the IPAQ[40–45] may be less applicable to the modified version used in this study although the pattern of intercorrelations among the IPAQ variables and with the PAES suggests adequate convergent validity of the modified IPAQ in this study. Relatedly, it would have been useful to measure affective response to varying levels of PA intensity, which was not assessed in this study. Certain potential confounds (eg, medical disabilities) that could explain relations between affect and PA were not measured. However, some of these characteristics are rare in college students and are unlikely to have had a major effect on the findings. Lastly, in this preliminary study with a modest sample size, we did not correct for multiple comparisons, which raises the chances of type I error. However, this concern is somewhat offset as the findings were fairly consistent across multiple anhedonia measures and various PA indexes and some of the *P*-values were relatively extreme.

An important consideration is the generalizability of the current findings to other groups. This study included a convenience sample of college students, primarily aged 18–23 years, that was mostly in good physical health. The proportion of the sample that met recommended PA guidelines (78%) is higher than 2007 general population estimates of US adults (65%) as well as estimates of individuals in the 18–24 age bracket (74%).[55] Thus, it is uncertain if associations between anhedonia and PA extend to groups who are less active overall. Similarly, it is uncertain if pleasure and the enjoyment of PA are equally as important in older adults as compared to younger adults. In addition, the sample had a higher proportion of individuals of Asian, Middle Eastern, and multiracial descent than the general US population. Finally, the current sample was educationally homogenous, which differs from the educational diversity among the general US population. It is possible that these important demographic characteristics may impact the role of pleasure in PA. Thus, it will be important for future work to examine the relation between anhedonia and PA in larger representative samples and to explore demographic moderators of this association.

Limitations not withstanding, this study presents a novel approach to understanding the affective correlates of PA. The findings point toward deficient pleasure as a potential novel affective mechanism in PA. If these findings are replicated and extended, they could be useful for informing the generation of new health promotion and mental health interventions. Specifically, pleasure-enhancement interventions that help individuals increase contact with pleasurable healthy reinforcers (eg, behavioral activation treatment[53]) or teach mindfulness techniques to savor the experience of pleasant events (eg, positive psychotherapy[54]) may be useful to incorporate into treatment packages for the promotion of

PA in some populations. Furthermore, exercise interventions may be useful adjunctive treatments for depressed patients with anhedonic features.[50]

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Table 1

Items From Anhedonia Scales

Tripartite Pleasure Inventory Items
Electronic entertainment activities, such as watching TV or movies, listening to music, surfing the Internet, or playing video games
Eating food that is particularly tasty or delicious
Noticing beautiful things in your environment, such as a sunset, outdoor landscape, architecture, or attractive people
Spending time with people you are close to, such as family and friends
Personal hobbies, such as reading, painting, following sports, or collecting things
Learning new information or skills
Going to an event, such as a concert, movie, play, or sporting event
Romantic or sexual activities
Socializing with other people in-person or over the phone and Internet
Accomplishing things, such as work, taking care of family, or housework
Snaith Hamilton Pleasure Scale Items
I would enjoy my favorite television or radio program
I would enjoy being with my family or close friends
I would find pleasure in my hobbies or pastimes
I would be able to enjoy my favorite meal
I would enjoy a warm bath or refreshing shower
I would find pleasure in the scent of flowers or the smell of a fresh sea breeze or freshly baked bread
I would enjoy seeing other people’s smiling faces
I would enjoy looking good when I have made an effort with my appearance
I would enjoy reading a book, magazine, or newspaper
I would enjoy a cup of tea or coffee or my favorite drink
I would find pleasure in small things, eg, a bright sunny day or a telephone call from my friend
I would be able to enjoy a beautiful landscape or view
I would get pleasure from helping others
I would feel pleasure when I receive praise from others

Table 2

Descriptive Statistics and Intercorrelation of Physical Activity Variables

Intercorrelations (*r*)													
	M(SD)	**1.**	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**	**11.**	**12.**	**13.**
1. SHAPS	8.82 (5.46)													
2. TPI-R	1.14 (0.50)	.44****												
3. PAES-Total Score	4.0 (0.7)[a]	−.12	−.28***											
4. PAES-Reward Subscale	3.9 (0.7)[a]	−.17*	−.32****	.94****										
5. PAES-Aversive Subscale	4.1 (0.8)[a]	−.05	−.20*	.91****	.73****									
6. Walking days/wk	5.5 (2.1)	−.27***	−.21**	.25**	.22**	.24**								
7. Walking min/day	80.9 (66.8)	−.12	.06	−.06	−.06	−.05	.27**							
8. Walking min/wk	476 (432)	−.12	.04	−.01	−.01	−.02	.64****	.91****						
9. Moderate PA days/wk	3.0 (2.3)	−.20*	−.24**	.09	.09	.07	.00	−.04	.07					
10. Moderate PA min/day	58.6 (66.5)	−.17*	−.25**	.13	.14	.09	.04	.15	.10	.83****				
11. Moderate PA min/wk	241 (341)	−.20*	−.25**	.12	.13	.09	.01	.10	.05	.93****	.98****			
12. Vigorous PA days/wk	2.3 (2.0)	.00	−.16*	.37****	.38****	.29***	.15	−.24**	−.14	.32**	.20*	.23**		
13. Vigorous PA min/day	50.0 (43.8)	.02	−.17*	.40****	.40****	.33****	.13	−.16*	−.07	.28***	.21*	.23**	.88****	
14. Vigorous PA min/wk	164 (172)	.01	−.18*	.40****	.42****	.33****	.13	−.19*	−.10	.30***	.21*	.24**	.95****	.98****

*P< .05;

**P < .01;

***P < .001;

****P < .0001

Note.

N = 157

Samples sizes range from 129 to 157 across analyses due to missing data. PA = Physical Activity. PAES = Physical Activity Enjoyment Scale.

[a]Average score per item (possible range 1 – 5)

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Table 3

Interrelations Between Anhedonia (SHAPS), Affective Response to Physical Activity, and Physical Activity Behaviors

	Predictor				Mediation: SHAPS → PAES-Reward → PA			
	SHAPS		PAES		Indirect Effect		Remaining Direct Effect	
Outcome	β^a	β^b	β^a	β^b	β^a	β^b	β^a	β^b
PAES-Total	−.12	−.13	-	-	-	-	-	-
PAES-Reward	−.17**	−.18**	-	-	-	-	-	-
PAES-Aversive	−.05	−.05	-	-	-	-	-	-
Walking								
Days per week	−.27****	−.22***	.22***	.24***	−.04**	−.04**	−.24***	−.18**
Minutes per day	−.12	−.11	−.06	.06	-	-	-	-
Minutes per week	−.12	−.13	−.01	.01	-	-	-	-
ModeratePA								
Days per week	−.20**	−.21**	.09	.08	−.01	−.02	−.19**	−.20**
Minutes per day	−.17**	−.16*	.14	.13	−.02	−.02	−.15*	−.13
Minutes per week	−.20**	−.19**	.13	.12	−.02	−.02	−.18**	−.17*
Vigorous PA								
Days per week	.00	−.02	.38****	.38****	-	-	-	-
Minutes per day	.02	.01	.40****	.40****	-	-	-	-
Minutes per week	.01	−.01	.42****	.41****	-	-	-	-

* P < .10;

** P < .05;

*** P < .01;

**** P < .001

Note.

N = 157

Samples sizes range from 129 to 157 across analyses due to missing data. Dash indicates that the analysis was not performed either because it was not relevant or because there was no association between SHAPS and the PA-related behavior outcome. Indirect effect = mediational effect of SHAPS on IPAQ outcome through PAES-Reward. Direct effect = effect of SHAPS on IPAQ outcome after adjusting for PAES-Reward. PA = Physical Activity. PAES = Physical Activity Enjoyment Scale. SHAPS = Snaith Hamilton Pleasure Capacity Scale. CESD = Center for Epidemiologic Studies Depression Scale.

[a] Unadjusted standardized regression parameter

[b] Adjusted standardized regression parameter after controlling for gender and CESD score

Table 4

Interrelations Between Anhedonia (TPI-R), Affective Response to Physical Activity, and Physical Activity Behaviors

	Predictor				Mediation: TPI-R → PAES-Reward → PA			
	TPI-R		PAES		Indirect Effect		Remaining Direct Effect	
Outcome	β^a	β^b	β^a	β^b	β^a	β^b	β^a	β^b
PAES-Total	−.28****	−.29****	-	-	-	-	-	-
PAES-Reward	−.32****	−.34****	-	-	-	-	-	-
PAES-Aversive	−.20*	−.20***	-	-	-	-	-	-
Walking								
Days per week	−.21***	−.16**	.22***	.24***	−.07***	−.08**	−.15*	−.09
Minutes per day	.06	.09	−.06	.06	-	-	-	-
Minutes per week	.04	.07	−.01	.00	-	-	-	-
ModeratePA								
Days per week	−.24***	−.25***	.09	.08	−.03	−.03	−.24***	−.25***
Minutes per day	−.25***	−.24***	.14	.13	−.05	−.05	−.23***	−.22*
Minutes per week	−.25***	−.25***	.13	.12	−.04	−.04	−.24***	−.24**
Vigorous PA								
Days per week	−.16**	−.17**	.38****	.40****	−.12****	−.14****	−.05	−.04
Minutes per day	−.17**	−.18**	.40****	.41****	−.13****	−.13****	−.05	−.05
Minutes per week	−.18**	−.19**	.42****	.43****	−.13****	−.14****	−.05	−.06

* P < .10;

** P < .05;

*** P < .01;

**** P < .001

Note.

N = 157

Samples sizes range from 129 to 157 across analyses due to missing data. Dash indicates that the analysis was not performed either because it was not relevant or because there was no association between TPI-R and the PA-related behavior outcome. Indirect effect = mediational effect of TPI-R on IPAQ outcome through PAES-Reward. Direct effect = effect of TPI-R on IPAQ outcome after adjusting for

PAES-Reward. PA = Physical Activity. PAES = Physical Activity Enjoyment Scale. TPI-R = Tripartite Pleasure Inventory-Responsiveness Subscale. CESD = Center for Epidemiologic Studies Depression Scale.

[a] Unadjusted standardized regression parameter

[b] Adjusted standardized regression parameter after controlling for gender and CESD score.