J Behav Med (2021) 44:579–590
https://doi.org/10.1007/s10865-021-00229-7

Relations between social comparisons and physical activity among women in midlife with elevated risk for cardiovascular disease: an ecological momentary assessment study

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Received: 17 March 2021 / Accepted: 23 April 2021 / Published online: 12 May 2021

Abstract Women in midlife (ages 40–60) show decreases in physical activity (PA) that exacerbate risk for cardiovascular disease. Social comparisons (i.e., self-evaluations relative to others) are known to influence PA in other groups, but their association in this population is unknown. The present study used ecological momentary assessment to examine this relation among women in midlife with hypertension or another CVD risk condition ($N = 75$, $M_{BMI} = 34.0$ kg/m^2). Participants completed 5 surveys per day and wore tri-axial accelerometers for 10 days. PA engagement was lower after women reported more comparisons than were typical for them (7–14% reductions in PA for each additional comparison). These relations varied across days of observation and relations were *positive* on 34–58% of days. Findings call for careful consideration of how best to harness any potential benefits of social comparison for promoting PA in this and other groups.

Keywords Physical activity · Midlife · Women's health · Social comparison

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During midlife (ages 40–60; Brim et al., 2019), women are at increased risk for cardiovascular disease due to biological factors consequent to aging, menopause, weight gain, and associated health conditions (e.g., hypertension; Kapoor et al., 2017). Women also decrease engagement in cardioprotective behaviors such as physical activity (PA) during this period (Davidson et al., 2010; Dugan et al., 2018). This decrease exacerbates the PA gender gap that exists throughout the lifespan (with men engaging in more PA than women; Appelman et al., 2015; Troiano et al., 2008) and further raises midlife women's cardiovascular risk. Promoting PA in this population could meaningfully reduce this risk (Jeong et al., 2019), though few existing interventions show long-term efficacy (Murray et al., 2017). Improving on the current understanding of barriers to and facilitators of PA among midlife women could point to novel intervention approaches for this population.

Consistent with several theories of health behavior, including social-cognitive theory (Bandura, 1998) and Midlife Women's Attitudes Toward Physical Activity Theory (MAPA; Im et al., 2010), perceptions of the social environment are key to PA engagement in this group. For example, more (vs. less) positive perceptions of social norms for PA are associated with greater PA engagement among women in midlife (Im et al., 2011, 2017; Janssen et al., 2014). *Social comparisons*, or self-evaluations relative to others (Festinger, 1954) represent a specific set of social perceptions that may have similar influences on midlife women's PA, but these relations have received little attention. Social comparisons are common in daily life and can be made across a range of dimensions (e.g., appearance, abilities, health behaviors). They can occur deliberately or automatically (Gilbert et al., 1995) and provide the comparer with information about their status in a given domain (Festinger, 1954). For example, comparing to someone perceived as

"doing better" than the self (i.e., upward comparison) can demonstrate that improvement is possible and afford guidance for achieving similar outcomes (Bandura, 1998). Comparing to someone perceived as "doing worse" than the self (i.e., downward comparison) can provide satisfaction with one's own achievements and information about how to avoid undesirable outcomes (Wills, 1981). Comparing to someone perceived as "doing about the same" as the self (i.e., lateral comparisons) can show the comparer that they are keeping up with peers and thereby offer comfort (Helgeson & Mickelson, 1995).

These expected benefits appear to serve as the rationale for including social comparison opportunities in PA interventions (i.e., exposure to information about other participants' PA engagement; Michie et al., 2011), and there is some evidence that comparison outperforms other social behavior change techniques such as support (e.g., Patel et al., 2016; Zhang et al., 2016). However, comparisons are not universally positive: upward comparisons can prompt dejection by underscoring the comparer's inferiority, and downward comparisons may trigger anxiety by illustrating an unavoidable future state (Buunk & Ybema, 1997). Less is known about responses to lateral comparisons, though negative reactions to them also may be possible. Importantly, the vast majority of existing work on the consequences of social comparisons focus on self-reported outcomes, such as thoughts about engaging in PA (Arigo, Mogle, et al., 2020; Thøgersen-Ntoumani et al., 2018). It is unclear which, if any, types of comparisons are associated with changes in observable PA behavior. Additional information about relations between social comparison types and objectively assessed PA engagement is needed to fill this gap, to advance the present understanding of social comparison's role in everyday experiences and to define the circumstances under which comparisons might be appropriate or useful for PA intervention in at-risk groups such as women in midlife.

In particular, it is not clear whether any relation between comparison type and PA engagement represents stable differences between people versus fluctuation within the same person at different times (i.e., variability between- vs. within-persons). Between-person relations are described in the majority of existing work focused on social comparisons and health outcomes (e.g., from cross-sectional surveys or group-based randomized trials), and indicate *for whom* comparisons might be useful for increasing PA. In contrast, within-person relations can identify *times when* or *contexts in which* comparisons might be useful for this purpose (cf. Dunton, 2017; Smyth et al., 2017). Relations between social comparisons and PA at each level have distinct implications for social comparison as a target of PA interventions.

For example, knowing which women are likely to make comparisons that are negatively associated with subsequent PA (between-person) could help to target interventions toward women who would benefit from efforts to mitigate this association; such intervention may not be appropriate or useful for all women. In contrast, identifying the type(s) of comparison that are associated with less (vs. more) subsequent PA (within-person) could be useful for determining when or under what circumstances intervention skills or content would be most appropriate. Further, it is rare to see published work on social comparison that probes these effects by examining whether within-person relations with outcomes are consistent (vs. variable) across assessments, which could highlight the variety of potential behavioral responses (e.g., certain types of comparisons predicting greater and less PA engagement under different circumstances), and thus, the utility of a more nuanced approach to social comparisons in PA interventions.

Limited work using designs that capture within-person variation (e.g., ecological momentary assessment [EMA]; Smyth & Stone, 2003) show that college women engage in *less* PA on days when they report experiencing (vs. not experiencing) a comparison of their health habits (across comparison directions; Arigo, Pasko, et al., 2020), though the likelihood of engaging in exercise to control weight is *higher* at and subsequent to times when they experience upward comparisons of appearance (Drutschinin et al., 2018). These findings indicate that young women can differentiate days and times when they do versus do not make comparisons, and that even when the comparison dimension is not PA, these distinct contexts are associated with PA outcomes at the within-person level. As noted, however, social comparisons are examined less often among women in midlife, particularly with respect to their relations with objectively assessed PA engagement. Extant evidence indicates that body comparisons are common in this age group and are associated with broader self-perceptions of appearance (which could motivate or hinder PA; Thompson & Bardone-Cone, 2019; Watt & Konnert, 2020), though comparisons in domains other than appearance have received little attention.

Aims of the present study

Social comparisons are proposed to predict health behaviors and vary within-person, though very little research has examined relations between comparisons and health behaviors at the within-person level (Arigo, Mogle, et al., 2020) or in at-risk groups such as women in midlife. To begin to address this gap, the overarching goal of this 10-day EMA study was to examine within-person relations between social comparisons and PA among midlife women with elevated risk for CVD – both overall, and the extent to which these relations differed across assessments. Specifically, the first aim of this study was to test for overall within-person relations between the number of social comparisons reported and subsequent PA

engagement, using the total number of comparisons reported at each assessment and the frequency reported separately for each comparison direction. The second aim was to determine whether these relations varied within women across days. As existing work has shown both positive and negative consequences of comparisons, and as we expected these relations to vary across days, we did not have a priori hypotheses about the directions of these relations. Given that different intensities of PA have distinct implications for cardiovascular risk (Kokkinos & Myers, 2010), outcomes were subsequent PA engagement in minutes of both light and moderate-to-vigorous PA. Engagement was assessed objectively in the 30 min after each survey was completed.

Methods

Recruitment and participants

Women were eligible to participate if they were between 40 and 60 years old (inclusive) and reported one or more of the following CVD risk factors: smoking (current or quit within the past three months), hypertension or prehypertension, prediabetes or type 2 diabetes, hyperlipidemia or hypercholesterolemia, or metabolic syndrome. Additional inclusion criteria required fluency in English, not currently pregnant, no comorbid medical conditions or psychiatric symptoms that would impede participation (e.g., injury, active psychosis), not currently engaged in weight loss or other behavior change efforts that might influence PA engagement, and access to a mobile device. Electronic advertisements appeared on community and news websites and were sent to students and employees at the supporting institutions. Active recruitment also took place in affiliated primary care offices; after chart review, eligible patients were given information about the study and invited to complete a brief telephone call to discuss their interest (see Fig. 1 for an enrollment flowchart). The final sample of 75 women (M_{Age} = 51.61) was 22% Black, 2% Latina, 1% Asian-American, and 73% White, with 3% identifying as mixed or other. The largest subsets of participants were married (56%), identified as post-menopausal (41%), and reported a diagnosis of hyperlipidemia or hypercholesterolemia (52%). Average BMI was 34.02 (SD = 7.13) and the majority of participants had BMIs in the obese category (59%). Additional demographic information can be found in Table 1.

Measures

Demographic information

Height and weight were measured by research staff at participants' setup visits using a digital Seca© scale and stadiometer. Measured height and weight were used to calculate BMI (kg/m^2). Other demographics such as race and menopause status were assessed with a baseline survey, completed before the initial setup appointment.

Momentary survey: social comparison

The wording of social comparison items was guided by the references below and refined through formative work with the population of interest (Arigo et al., 2021). At each survey, participants were asked whether they had made a how many times they made social comparisons since they woke up (first survey of the day) or in the last 3 h (all subsequent surveys of the day), using numeric text entry (Leahey et al., 2007). Follow-up items included what aspect(s) of the self they compared (e.g., appearance, health habits, abilities, etc.; Arigo, Pasko, et al., 2020; Wheeler & Miyake, 1992) and the numbers of comparisons in each direction (i.e., *people who seem to be doing better than I am* [upward], *people who seem to be doing about the same as I am* [lateral], or *people who seem to be doing worse than I am* [downward]; numeric text entry for each; Leahey et al., 2007).

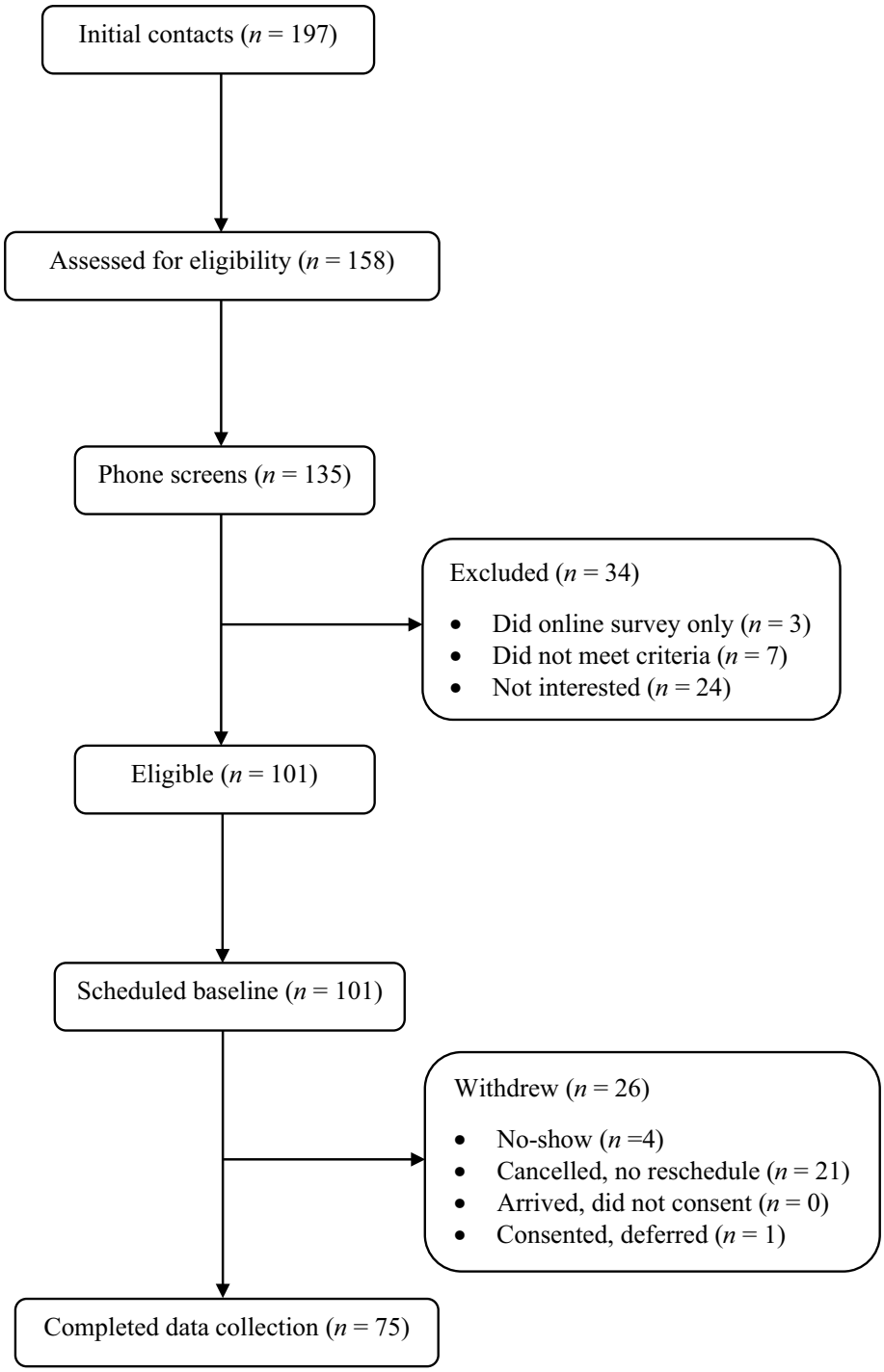
Physical activity monitor

PA was assessed using ActiGraph GT3X tri-axial accelerometers (ActriGraph Corp., Pensacola, FL), worn in alignment with the dominant hip during waking hours. PA parameters of interest were minutes of light, moderate, and vigorous activity for the 30 min following survey completion. This interval was selected to represent a proximal window of interest for both light PA and MVPA, though the effects reported below are consistent across 30-, 60, and 120-min intervals. Moderate and vigorous minutes were combined to estimate total minutes in moderate-to-vigorous intensity physical activity (MVPA). These values were calculated using the ActiPro package for RStudio (Dzubur, 2020). Non-wear was defined as periods with 60 or more continuous minutes without activity counts (i.e., activity counts = 0; cf. Pickering et al., 2016); these periods were excluded from analyses. MVPA cut points were those proposed by Matthews et al. (2008; see Arigo, Pasko, et al., 2020).

Procedures

The full protocol for this study is available (Arigo, Brown, et al., 2020a) and a summary is provided here. All procedures were approved by Institutional Review Boards at the supporting institutions; all data were collected between February 2019 and March 2020 (i.e., prior to the onset of the COVID-19 pandemic). Potential participants completed a screening call to confirm eligibility and schedule a setup appointment. These appointments included informed consent procedures and written documentation of consent,

Fig. 1 CONSORT diagram



assessment of height and weight, introduction and testing of the accelerometer and momentary surveys, and instructions for identifying social comparisons. Participants were provided with examples of social comparisons and were encouraged to generate their own examples for discussion. At the end of the setup appointment, participants were scheduled for an exit interview to return the accelerometer and provide feedback on their experience. Staff then scheduled survey prompts to appear as text messages to the participant's smartphone, with embedded weblinks to each momentary survey. Responses were signal-contingent, such that participants reported on their experiences only in response to survey prompts. Surveys were scheduled around five semi-random times that fell between participants' wake and bed times, so that they did not appear at the same times each day; survey schedules did not differ between weekdays

Table 1 Participant demographics (n = 75)

	M (SD)		
Age	51.61 (5.43)		
BMI	34.02 (7.13)		
Number of CVD risk factors	1.63 (0.82)		
Racial Identification	*n (%)*	*Marital Status*	*n (%)*
Caucasian/White	55 (73%)	Never married	12 (16%)
African American/Black	16 (22%)	Widowed	4 (5%)
Asian or Pacific Islander	1 (1%)	Divorced	11 (15%)
Hispanic/Latina	2 (3%)	Separated	4 (5%)
Mixed/Other	1 (1%)	Married	44 (59%)
Highest educational level		*Menopause Status*	
High School or GED	7 (9%)	Pre-menopause	14 (20%)
Associate's degree, technical degree, or partial college	16 (21%)	Perimenopause	16 (23%)
Bachelor's degree	24 (32%)	Post-menopause	29 (39%)
Graduate/professional degree	28 (37%)	Other (e.g., surgical intervention)	12 (17%)
CVD risk condition(s)		*Household Income*	
Hypercholesterolemia or hyperlipidemia	39 (52%)	< $25,000	5 (7%)
Hypertension or prehyptertension	35 (47%)	$25,000-$50,000	12 (16%)
Type 2 diabetes	30 (40%)	$50,000-$75,000	12 (16%)
Metabolic syndrome	8 (11%)	> $75,000	45 (61%)
Smoker (or quit in last 3 months)	10 (14%)		

and weekends. Participants were asked to complete each survey within 1 h of receiving it. Participants received $15 for attending the baseline appointment and $30 when they returned for follow-up. Those who returned their accelerometers and completed more than 80% of EMA surveys received an additional $10 bonus at follow-up.

Statistical approach

Sample size was calculated for within-person multilevel models (described below), following stimulations by Maas and Hox (2005). Using conservative estimates from previous studies and pilot work with the population of interest, a target sample size of 100 participants (level 3) with 10 days of observation (level 2) five times per day (level 1) exceeded thresholds for detecting within-person relations (level 1). Precautions against the spread of COVID-19 prevented recruitment and enrollment past March 2020, however. The final sample of 75 women with up to 50 observations each provided 3,750 possible observations and still afforded power > 0.80 for within-person tests. Average completion across all surveys was 90% ($SD = 9.0\%$) and average completion in the designated 1-h time window was 80% ($SD = 14.0\%$); only those surveys completed in this window were considered valid and included in analyses. Valid accelerometer data for the 30 min after valid surveys was available for 1482 observations.

Missingness

Missing data patterns were evaluated with bivariate correlations (percent of completed surveys) and SAS PROC GLIMMIX (binary variable indicating momentary survey completion). Missingness for surveys was positively associated with BMI ($r = 0.24$, $p = 0.03$) and weekend days (versus weekdays; OR = 1.41, 95% CI 1.12–1.78). Overall missingness was marginally associated with age ($r = 0.21$, $p = 0.07$), but was not related to other demographic characteristics ($ps > 0.10$) or to survey of the day or day in study ($0.92 < ORs < 1.10$). Missingness specific to social comparison items showed the same pattern. Valid accelerometer data were most likely to be missing after survey #4 of the day (usually early evening; OR = 0.02, 95% CI 0.01–0.03).

Interrelations between predictors

We examined whether at moments when a participant reported one type of social comparison, they were likely to also report other types. Correlations ranged from 0.23 to 0.68 with the highest correlation between upward and downward comparisons (all $ps < 0.01$). As these correlations suggest moderate associations between related but distinct experiences, which is appropriate for the context, the number of each comparison was treated as an independent predictor of PA. Descriptive analyses of variability in predictors (numbers of comparisons overall, upward, lateral, and downward) used empty multilevel

mixed models to estimate the proportion of variance accounted for at each level using the intraclass correlation coefficient (ICC).

Primary analyses

Multilevel models were used to address the nested structure of EMA data. Models included three levels to account for complex nested structure (surveys nested within days and days nested within persons); comparisons for each model showed significantly improved model fit with (vs. without) the day level ($ps < 0.01$). Analyses were conducted in SAS 9.4 using a Poisson distribution (log link) in PROC GLIMMIX (SAS Institute Inc., Cary, NC) to address the non-normal distribution of PA engagement; all models employed likelihood approximation techniques to account for missingness (Laplace). Age, BMI, weekday versus weekend, and survey of the day were included as covariates in all models.

For each continuous predictor of interest (i.e., overall number of comparisons and numbers of upward, lateral, and downward comparisons), variance was differentiated by calculating each person's mean across EMA responses (between-person) and the difference between this person mean and the response on a given survey (within-person; i.e., person-mean centering; Hoffman, 2015). This allows for interpretation of within-person social comparisons as *at times when a participant made more comparisons than their typical number*, controlling for between-person means. Statistical significance for all fixed effects was set to $p < 0.05$.

With respect to the second study aim (i.e., within-person variability in relations between comparisons and PA), models included random slopes for each predictor of interest. A significant random slope would indicate that relations between predictors and PA outcomes varied within women across assessment days. Model fit tests were conducted using the -2 loglikelihood (-2LL) to determine whether the random slope improved model fit over a model constraining slopes to be the same across participants. Differences between -2LL follow a chi-square distribution (χ^2) to determine whether the improvement was significant. For models where including the random slopes significantly improved fit, the plausible range of slopes and the percentage of days with positive slopes (indicating greater PA after social comparison reports) and negative slopes (indicating less PA after social comparison reports) were calculated, to aid in interpretation. Effect sizes are expressed as rate ratios indicating relative rates of PA engagement across different levels of the predictor.

Results

Across participants and moments, social comparisons were reported at 21% of surveys that were completed in the designated 1-h time window. Participants reported an average of 0.36 comparisons per survey ($SE = 0.05$) and the number of comparisons at a given survey ranged from 0 to 10. An ICC = 0.20 indicated that 20% of the variability in the overall number of comparisons reported was attributable to stable, between-person differences, whereas 80% was attributable to within-person fluctuation (and error). With respect to comparison direction, upward comparisons were most common (reported at 11% of all valid surveys), followed by lateral and downward comparisons (8% and 9% respectively). Between-person stability in the number of comparisons per direction was minimal (i.e., ICCs < 0.12; see Table 2). Comparisons of abilities (e.g., skills, intelligence) were most common (9% of valid surveys), followed by comparisons of appearance (7%) and emotional reactions (6%; see Table 2).

Number of comparisons and PA engagement

Participants had lower rates of light PA subsequent to reports with more comparisons than usual (overall; $p < 0.001$, RR = 0.93, 95% CI 0.89–0.97) and with reports of more upward or lateral comparisons than usual. Each additional upward comparison corresponded to a 14% lower rate of light PA ($p < 0.001$, RR = 0.86, 95% CI 0.81–0.93) and each additional lateral comparison corresponded to a 7% lower rate of light PA ($p = 0.02$, RR = 0.93, 95% CI 0.87–0.99; see Table 3). Rates of both light PA and MVPA also were lower after surveys with more reported downward comparisons than usual, with each additional downward comparison corresponding to 14% lower rate of light PA ($p = 0.002$; RR = 0.86, 95% CI 0.78–0.95) and MVPA ($p = 0.01$, RR = 0.86, 95% CI 0.76–0.97; see Table 3). Rate of engagement in MVPA was not significantly associated the numbers of comparisons overall, upward, or lateral ($ps > 0.60$).

Variability in within-person relations

Adding random slopes to the models predicting PA from the number of comparisons reported (i.e., allowing the relation between comparisons and PA to vary across days) significantly improved model fit (all $ps < 0.01$). For example, the relation between overall number of comparisons and light PA ($\chi^2[1] = 30.71$) showed a plausible range of 95% slopes across days from -0.82 to 0.69 ($SD = 0.37$); this relation was negative for 56% of days and positive for 44%. The plausible range of slopes for the relation between overall number of comparisons and MVPA ($\chi^2[1] = 107.58$) was -1.12 to 1.28, with a negative relation on 45% of days and a positive relation on 55% (see Table 3).

Table 2 Descriptive statistics for social comparison reports

Social comparison *(Any Time in Reporting Window)*	*n (%) YES of all valid surveys*	*n (%) YES of surveys with SC reported*	*ICC*	*B (SE)*
Any comparison	617 (21%)		0.20	0.36 (0.05)
Upward comparisons	322 (11%)	322 (52%)	0.11	0.15 (0.02)
Lateral comparisons	252 (8%)	252 (41%)	0.11	0.14 (0.02)
Downward comparisons	261 (9%)	261 (42%)	0.07	0.08 (0.01)

Occurrence by type	Any time in window*n (%)*	Most recent*n (%)*
Upward	322 (11%)	234 (43%)
Lateral	252 (8%)	164 (30%)
Downward	261 (9%)	145 (27%)
Appearance	197 (7%)	82 (17%)
Health habits	155 (5%)	51 (11%)
Status	166 (6%)	51 (11%)
Emotion regulation	181 (6%)	79 (17%)
Personality	140 (5%)	35 (7%)
Abilities	279 (9%)	135 (28%)
Other	54 (2%)	44 (9%)

n (%) yes indicates report of comparison occurrence, out of 2967 valid surveys (any time window) and 617 surveys where comparisons were reported (most recent comparison). ICC = intraclass correlation coefficient

Relations between the number of comparisons in each direction and PA showed similar patterns, though the proportion of days with negative slopes varied across direction of comparison. For relations between number of upward comparisons and light PA ($\chi^2[1] = 11.48$) and MVPA ($\chi^2[1] = 64.16$), the plausible ranges of slopes across days were -0.83 to 0.67 ($SD = 0.37$; negative for 58% of days) for light PA and -1.08 to 1.32 ($SD = 0.60$; negative for 42% of days) for MVPA, respectively. For relations between number of lateral comparisons and light PA ($\chi^2[1] = 7.93$) and MVPA ($\chi^2[1] = 26.89$), the plausible ranges of slopes across days were -0.76 to 0.68 ($SD = 0.36$; negative for 54% of days) for light PA and -1.08 to 1.23 ($SD = 0.59$; negative for 43% of days) for MVPA, respectively. For relations between number of downward comparisons and light PA ($\chi^2[1] = 9.30$) and MVPA ($\chi^2[1] = 21.85$), the plausible ranges of slopes across days were -0.90 to 0.60 ($SD = 0.37$; negative for 66% of days) and -1.37 to 1.07 ($SD = 0.62$; negative for 60% of days), respectively.

Discussion

Understanding psychosocial determinants of PA in midlife women's daily lives could help to improve PA promotion efforts for this population. Toward this goal, the present study is the first to identify social comparison as a predictor of PA engagement in this population and to describe this relation at the within-person level. In addition, as it is one of the few studies of relations between social comparison and objectively assessed PA more broadly, the present findings also offer important contributions to our understanding of basic social comparison processes and their implications for daily experiences.

Because comparisons can happen without full awareness and may be perceived as socially undesirable (Helgeson & Taylor, 1993), it can be difficult to estimate their frequency in the natural environment and accurately capture individual differences and within-person variability. EMA and other intensive assessment methods can reduce retrospective recall biases and improve the accuracy of these estimates (Smyth & Stone, 2003), though little existing research explicitly describes variability at different levels (Arigo, Mogle, et al., 2020). Findings from the present study indicate that comparisons occurred approximately twice per day, on average, and that the majority of variability in their frequency was within-person. Thus, although some women may consistently experience more comparisons than others, the frequency of comparison experiences varies widely for individual women.

Specifically, overall within-person relations between the number of social comparisons and subsequent PA were negative: at times when women experienced more comparisons than usual, they were 7%-14% less active in the following 30 min for each additional comparison. This pattern held across upward, downward, and lateral comparisons, particularly for light PA, suggesting that naturally occurring comparisons may be detrimental (rather than beneficial) for midlife women's subsequent PA. Importantly, however, adding a random slope improved model fit for each of these within-person

Table 3 Multilevel model estimates for tests of relations between social comparison and physical activity engagement 30 min after each survey

	Minutes of light activity	Minutes of MVPA
Total number of comparisons	*B (SE)*	*B (SE)*
Intercept	1.56 (0.06)**	1.19 (0.08)**
BMI	0.002 (0.006)	0.0007 (0.007)
Age	0.004 (0.007)	−0.004 (0.009)
Weekend vs. weekday	0.76 (0.05)	−0.03 (0.07)
Survey of the day	−0.21 (0.02)**	−0.25 (−0.02)**
Between-person effect	−0.11 (0.10)	−0.04 (0.13)
Within-person effect	−0.07 (0.02)**	0.005 (0.03)
	Range of Slopes (% Positive)	*Range of Slopes (% Positive)*
Random effects	−0.82–0.69 (44%)	−1.12–1.28 (55%)
Number of upward comparisons	*B (SE)*	*B (SE)*
Intercept	1.57 (0.06)**	1.19 (0.08)**
BMI	0.002 (0.006)	0.001 (0.007)
Age	0.003 (0.007)	−0.005 (0.009)
Weekend vs. weekday	0.08 (0.05)	−0.02 (0.07)
Survey of the day	−0.21 (0.02)**	−0.25 (0.02)**
Between-person effect	0.012 (0.01)	−0.02 (0.13)
Within-person effect	−0.15 (0.03)**	0.02 (0.04)
	Range of Slopes (% Positive)	*Range of Slopes (% Positive)*
Random effects	−0.83–0.67 (42%)	−1.08–1.32 (58%)
Number of lateral comparisons	*B (SE)*	*B (SE)*
Intercept	1.57 (0.06)**	1.19 (0.08)**
BMI	0.002 (0.006)	0.001 (0.007)
Age	0.004 (0.007)	−0.005 (0.009)
Weekend vs. weekday	0.07 (0.05)	−0.02 (0.07)
Survey of the day	−0.21 (0.02)**	−0.25 (0.02)**
Between-person effect	−0.12 (0.10)	−0.02 (0.13)
Within-person effect	−0.08 (0.03)*	−0.02 (0.04)
	Range of Slopes (% Positive)	*Range of Slopes (% Positive)*
Random effects	−0.76–0.68 (46%)	−1.08–1.23 (57%)
Number of downward comparisons	*B (SE)*	*B (SE)*
Intercept	1.57 (0.06)**	1.16 (0.08)**
BMI	0.002 (0.006)	0.0005 (0.007)
Age	0.004 (0.007)	−0.006 (0.009)
Weekend vs. weekday	0.08 (0.05)	−0.01 (0.07)
Survey of the day	0.21 (0.02)**	−0.24 (0.02)**
Between-person effect	−0.10 (0.10)	−0.02 (0.13)
Within-person effect	−0.15 (0.05)**	−0.15 (0.06)*
	Range of Slopes (% Positive)	*Range of Slopes (% Positive)*
Random effects	−0.90–0.60 (34%)	−1.37–1.07 (40%)

*$p < 0.05$, **$p < 0.01$

relations, indicating that their strength–and importantly, direction–varied within women between days. On 34% to 58% of days, women engaged in *more* PA, rather than less, after experiencing more comparisons than usual, and positive associations occurred more frequently for MVPA than light PA. Thus, experiencing additional comparisons may facilitate PA on some days and impede it on others. As this is a novel observation, additional research is needed to first determine the daily circumstances associated with positive versus negative relations between social comparisons and PA.

For example, the daily variability in relations between comparisons and PA may reflect shifts in women's deeper processing of their comparisons, such as identification with

versus contrast against their comparison targets. According to the Identification/Contrast Model (Buunk & Ybema, 1997), downward comparison prompts negative affect via a focus on similarities (i.e., identification, showing that an undesirable state is present or likely to occur for the self) and positive affect via a focus on differences (i.e., contrast, emphasizing the distance between current and undesired circumstances). Conversely, upward comparison prompts negative affect via contrast (as this increases the salience of the comparer's inferiority and distance from desired goals) and positive affect via identification (as the comparer's goals seem achievable; see Arigo et al., 2015; Buunk & Dijkstra, 2017). Subsequent PA engagement may follow a similar pattern; for example, PA may be greater on days when women have positive responses to additional downward comparisons (contrast) and lower on days when women have negative responses to additional downward comparisons (identification).

As negative responses to comparisons also can motivate behavior change (e.g., Mahler, 2018), however, it is unlikely that one type of response to additional comparisons consistently explains daily variation in their relations with women's PA. It is possible that positive responses to additional comparisons predict greater subsequent PA on some days and less subsequent PA on others, and similarly for negative responses. Existing research shows between-person differences in identification/contrast processes (Van der Zee et al., 2000) but has not examined within-person variability (Arigo, Mogle, et al., 2020), and lateral comparisons have received little attention with respect to this model. Additional insight into this aspect of variability in relations between comparisons and PA could provide critical information about the contexts in which comparisons are useful for PA promotion and point to their mechanisms of action among women in midlife (and potentially, more broadly).

Implications and future directions

The present study is one of the first in a series of steps necessary to fully understand relations between experiences of social comparisons and PA. For example, participants in this study were asked to report on their comparisons over the preceding 3-h time frame. Consequently, the specific timing of comparisons during these windows is unknown, as is whether they were engaged in PA at the times that their comparisons occurred. Additional work is needed to further clarify the temporal sequencing of naturally occurring comparisons and PA, as relations between these experiences may be even more complex than described here (e.g., on some days, making comparisons while active early in the day leads to additional comparisons and/or PA later in the day). Event-contingent recording allows participants to report on an experience such as comparison immediately after it occurs; this could be useful for improving the temporal specificity of comparisons, either alone or in tandem with signal-contingent recording (used in the present study; cf. Smith et al., 2020).

Another critical step in this line of work is to determine whether the observed within-person relations are causal and responsive to intervention. With respect to causality, experimental exposure to distinct comparison targets shows between-person differences in affect and outcomes such as desire for affiliation (Derlega et al., 2008; Gerber et al., 2018; Wood et al., 1985), as well as in reports of exercise motivation (Diel & Hofmann, 2019). As noted, existing literature also indicates that social comparison is used as a behavior change technique in many PA interventions (Bélanger-Gravel et al., 2011; Howlett et al., 2019), particularly in digital programs (e.g., smartphone applications; Arigo, Brown, et al., 2020b; Conroy et al., 2014), and that comparison can be an effective mechanism of PA behavior change (though it is captured between-person; Olander et al., 2013; Patel et al., 2016; Zhang et al., 2016).

Yet, the present findings highlight the possibility that there are times when social comparisons, and potentially, comparison-based intervention, may be more harmful than helpful. As little existing intervention work has examined experimental effects within-person, however, the optimal level of intervention (if one exists) has not been identified. Future work using intensive assessment designs could marry these related but independent lines of inquiry. For example, ecological momentary intervention (EMI) uses prompts during daily life to experimentally expose participants to stimuli, to assess causal relations in the natural environment (Heron & Smyth, 2010). A protocol to test the within-person effects of comparisons on PA could provide comparison exposure (e.g., to an upward PA target) via smartphone and assess subsequent changes in PA, as well as proposed mediators of this relation (e.g., identification, affective response) and contextual moderators (e.g., day of the week, days with vs. without experiences such as work stress). Similarly, a test of within-person intervention effects might provide guidance toward particular types of engagement with targets (e.g., contrast against a downward target) via smartphone and assess (1) to what extent this guidance was followed, and (2) subsequent changes in PA.

Together, such work would allow for investigation of mechanistic pathways between social comparison processes and PA outcomes and potential intervention effects, as well as differences in each by context, to identify time-sensitive methods of harnessing social comparison to promote PA. Although such steps are likely to have broad applications, this work may be especially relevant for PA promotion among midlife women, who cite lack of PA role models as a barrier to PA engagement (Cannioto, 2010)

and show particular interest in peer models of PA engagement as an intervention technique (Rowland et al., 2018).

Strengths and limitations

Strengths of this study include recruitment of an at-risk clinical sample, objective assessment of PA, and use of a preregistered EMA design to examine within-person relations between experiences of interest. Survey completion and PA monitor wear also were on par with or better than typical rates for EMA (cf. Maher et al., 2017) and were impressive for 10 days of assessment. However, precautions against the spread of COVID-19 resulted in a smaller sample size than intended, and despite efforts to recruit a diverse sample, majority of participants were Caucasian and highly educated. The 30-min time window selected for relations with objectively assessed PA was one of many that might be of interest (cf. Kim et al., 2020; Maher et al., 2018; Pickering et al., 2016), though we note that the observed relations were consistent across 30-, 60-, and 120-min windows.

Further, as indicated, the design of the present study did not focus on assessment of comparison at the time of its occurrence, and even women's most recent comparisons could have been any time in the 3-h reporting window. Consequently, the observed relations between social comparisons and PA outcomes may be specific to the act of reflecting and reporting on comparisons, which may have increased their salience at the moment of survey completion. Additional work using larger, more diverse samples and alternative designs (e.g., reporting at the time of the comparison event) are needed to clarify the boundaries of relations observed in the current study. As the present study focused on a narrow population with elevated CVD risk, an important aspect of future research will be to determine whether the relations observed here generalize to other populations or objectively assessed behaviors.

Conclusions

The experience of social comparison is common among women in midlife and may represent a useful target of PA intervention for this population. Importantly, although social comparison is recognized as an effective mechanism of PA behavior change (Olander et al., 2013), there is little evidence that existing interventions with social comparison components address individual or contextual differences in comparison consequences for PA (cf. Arigo, Brown, et al., 2020b). Findings from the present study show that, overall, experiencing more (vs. fewer) comparisons than usual is associated with less subsequent PA engagement among women in midlife, and thus, highlights the overall need for nuanced approaches to social comparison as a technique to promote PA behavior change in this population. Given that women engaged in more PA after experiencing additional comparisons on 34–58% of days, however, it will be critical to further determine when (and what types of) social comparisons may be helpful versus harmful for PA among women in midlife and other at-risk groups.

Acknowledgements The authors would like to thank M. Cole Ainsworth, Ph.D., Megan M. Brown, B.S., Kristen Pasko, M.A., Laura Travers, M.S., and Emily Vendetta, B.A. for their assistance with data collection and management.

Authors' contributions All authors contributed to study design and manuscript preparation. DA oversaw data collection and management. JAM conducted statistical analyses.

Data availability Data are available from the first author upon reasonable request.

Funding This work was supported by the National Heart, Lung, and Blood Institute (K23 HL136657, PI: Arigo).

Declarations

Conflict of interest The authors declare there is no conflict of interest.

Consent to participate Procedures were approved by the institutional review boards at Rowan University and Rowan School of Osteopathic Medicine.

Informed consent Rowan University and Rowan School of Osteopathic Medicine. All participants provided written informed consent.

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