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Interpersonal touch and the importance of romantic partners for older adults' neuroendocrine health

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ABSTRACT

Interpersonal touch is an essential aspect of human interaction that has the ability to regulate physiological stress responses. Prolonged exposure to stress can have cumulative multiphysiological effects; for example, allostatic load. Despite the increased susceptibility of social isolation for older adults, there is a paucity of research on the efficacy of touch in regulating stress responses among this population. It is also unknown whether touch confers benefits regardless of the person with whom it is shared. This study investigates the difference in physiological stress based on the frequency of touch (hugs, holding, or other close physical contact) shared with romantic partners as compared to other close adults (family, friends, and neighbours) in an older adult population. Data were analysed from 1419 respondents (aged 57–85 years) of the National Social Life, Health, and Aging Project (NSHAP) in 2005–2006. Principal components analysis determined whether the eight markers of allostatic load measured in the NSHAP function as a singular system or as distinct components. Analyses revealed three components of allostatic load: metabolic, cardiovascular, and neuroendocrine health. The results of multiple regression revealed that a higher frequency of interpersonal touch shared with romantic partners was associated with better neuroendocrine health ($\beta = 0.13$, $p = 0.004$) following adjustment for a variety of covariates (but not with better metabolic or cardiovascular health), with no associations apparent for touch from other close adults. These findings highlight the importance of promoting interpersonal touch with romantic partners for older adults' neuroendocrine health.

1. Introduction

Evidence suggests that close social relationships are associated with lower rates of morbidity and mortality (Holt-Lunstad et al., 2010; see Wang et al., 2023 for review), but the mechanisms underlying these associations and the specific elements of social relationships involved are not fully understood (Uchino, 2006). Notably, close personal relationships offer significant benefits in promoting health, particularly among older individuals. Theoretical perspectives emphasise the importance of emotional closeness (Antonucci et al., 2014), with a hierarchy of associations where spousal and family members provide the highest levels of support.

The physical act of touching serves as a means to indicate social proximity, surpassing the mere presence of others, and plays a role in alleviating distress and promoting a heightened sense of safety (Mikulincer et al., 2003; Eckstein et al., 2020). Consequently, research on reductions in physical contact, for example that resulting from social distancing measures implemented during the COVID-19 pandemic (Armitage and Nellums, 2020; Schneider et al., 2023), highlights the potential therapeutic value of non-sexual, affectionate touch in enhancing both physical and emotional wellbeing, particularly for individuals living alone. Von Mohr et al. (2021) found that individuals who practiced COVID-19 related social distancing for a longer duration expressed a greater desire for tactile experiences. Evidence suggests that unmet touch needs are associated with adverse outcomes. The absence of touch in adulthood has been linked to symptoms of mood disorders (Floyd, 2014), feelings of loneliness (Heatley Tejada et al., 2020), and a decline in general wellbeing (Debrot et al., 2021).

Complementary research also shows the therapeutic potential of touch for health. In Ditzen et al.'s (2007) study, a 10-minute session of physical touch, specifically a neck and shoulder massage between romantic partners prior to a psychosocial stressor, resulted in greater regulation of the female partner's heart rate and cortisol responses compared to verbal support. Effects were not examined in male partners.

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Heinrichs et al. (2003) propose that social interactions, including emotional support from others, contribute to the regulation of the hypothalamic-pituitary-adrenal (HPA) axis and the autonomic nervous system (ANS), leading to the suppression of physiological stress systems. Recent research proposes that interpersonal touch stimulates the oxytocinergic system, releasing oxytocin from hypothalamic nuclei to reduce stress (Uvnäs Moberg et al., 2020). It is suggested that physical touch may have a greater dampening effect on the activity of the HPA axis and ANS compared to verbal support (Ditzen et al., 2007). However, previous research has often overlooked the interdependence of physiological systems, and the available evidence primarily stems from laboratory-based intervention studies that focused predominantly on romantic couples.

What do we know about the factors that determine the frequency of interpersonal touch between individuals? Younger individuals prefer closer proximity to others and are more likely to engage in touch compared to their older counterparts (Upenieks and Schafer, 2022), indicating a negative association between age and preferred interpersonal distance. Additionally, emotionally close individuals are more likely to engage in touch, with broader areas of the body being touched and for more reasons (Suvilehto et al., 2015). The power of touch is particularly evident in romantic relationships, where activities such as hand holding between partners have been shown to result in increased brain-to-brain coupling (neural synchrony), and relief from pain as measured using electroencephalogram (EEG) (Goldstein et al., 2018). Moreover, increased touch from a spouse during discussions about stressors has been associated with lower stress levels, higher self-esteem, and greater perceptions of being able to overcome the stressor (Jakubiak and Feeney, 2019). The benefits of physical touch extend beyond romantic relationships. For instance, in healthcare settings, when nurses touch patients, it has been observed to improve sleep, blood pressure, respiratory rate and pain (Papathanassoglou and Mpouzika, 2012). Despite the advantages of touch from different sources, there is a need for direct comparisons examining the specific health benefits of touch received from a romantic partner compared to touch received from other adults.

Given the interrelation of various physiological systems in maintaining internal homeostasis and responding to stressors it is important to explore whether touch from romantic partners has unique or amplified associations compared to touch from other sources. This is particularly relevant in the context of allostasis, which refers to the internal adaptation of the body to maintain physiological stability by matching the internal milieu with environmental stressors (Sterling and Eyer, 1988). Over time, repeated exposure to stressful experiences can increase the body's allostatic load (AL), which represents the cumulative physiological burden resulting from the need for continuous adjustment to maintain allostasis (Seeman et al., 2001). High AL is often associated with poor cognitive and physical functioning (Karlamangla et al., 2002), cardiovascular disease (Seeman et al., 2001) and all-cause mortality (Goldman et al., 2006). AL is constructed by aggregating primary mediators (e.g., the stress hormone cortisol), indicating responses to environmental threats, and secondary mediators (e.g., raised blood pressure) reflecting prolonged biological adjustments often leading to disease (Seeman et al., 2001). The calculation of AL has been a topic of debate, with various approaches employed in the literature, including a count of multiple physiological markers (Seeman et al., 1997), canonical correlation (Karlamangla et al., 2002) and principal component analysis (PCA) (D'Alonzo et al., 2019). Among these approaches PCA offers the advantage of accounting for the underlying dimensions within the AL construct.

Evidence suggests that greater emotional support from friends and family is associated with lower AL in older age groups (Seeman et al., 2014). While the mechanisms that link emotional support and AL are presently unclear, we hypothesize, that interpersonal touch may play a role. This study will focus on the relationship between frequency of touch and AL, a measure of multisystem dysregulation, in older adults. In addition to age, this study examines if associations vary by whether touch is with romantic partners as compared to other close adults. We hypothesise that (1) more frequent physical touch will be associated with lower AL as compared to less frequent touch, and (2) this relationship will be stronger for frequent touch with romantic partners as compared to other close adults.

2. Methods

2.1. Participants

Data is used from the National Social Life, Health and Aging Project (NSHAP), a longitudinal study of a nationally (U.S.) representative sample of population-based, community-residing older adults. The NSHAP used interviews, biological samples and questionnaires from a randomly selected subset of respondents (O'Muircheartaigh et al., 2009). The survey included an oversampling of black, Hispanic, and oldest age individuals (75–85 years), using a complex, multistage area probability sampling design with post stratification. This analysis uses data from Wave 1 conducted between 2005 and 2006 with 3005 individuals, born between 1920 and 1947 (aged 57–85 years: 1455 men and 1550 women), achieving an overall response rate of 75.5%.

To the best of our knowledge, the NSHAP is also the only nationally representative study to include items about non-sexual touch between adults. For the analyses reported in this paper, only the base wave respondents ($n = 3005$) were utilised. There were 1419 respondents with no missing data for outcome variables, this was our analytic sample. A comparison of the analytic sample and the non-analytic ($n = 1586$) characteristics can be found in Appendices Table A.1. Their average age was 69.35 years ($SD = 7.76$), 48.98% were women, 74.58% were white and 66.53% had a romantic partner.

2.2. Touch Frequency

Two questions from the wave 1 questionnaire measured touch frequency with romantic partners and other close adults. The questions used were "In the last 12 months, how often have you engaged in the following activities: hugging, kissing, caressing, or other close physical contact with your partner?" and "In the last 12 months, how often have you engaged in the following activities: hugging, holding, or other close physical contact with another adult?". The NSHAP defined other adults as family members, neighbours and friends. Each question was treated as an independent exposure variable representing touch frequency with different individuals. Participants answered using a 7-point scale from 0 (never) to 6 (several times a week).

2.3. Allostatic Load (AL)

Principal components analysis (PCA) of AL was used to measure multi-system dysregulation. The NSHAP dataset includes eight AL biomarkers (see Table 1). The measures encompassed neuroendocrine system functioning (dehydroepiandrosterone (DHEA)); immune system functioning (c-reactive protein (CRP)); metabolic system functioning (glycosylated haemoglobin (HbA1c)); cardiovascular functioning (systolic blood pressure (SBP), diastolic blood pressure (DBP), and pulse rate); and anthropometric functioning (body mass index (BMI) and waist circumference). Availability and matching as closely as possible those markers employed in prior research determined the combination of markers used to construct AL (refer to Table 1). CRP was log transformed and DHEA was inverse transformed to better approximate a normal distribution based on data inspection.

2.4. Covariates

2.4.1. Sexual Touch

Sexual touch was a categorical variable with three groups: (1) no sex

Table 1
Individual components of the AL index in the NSHAP.

Biomarkers to be used in this study (outcomes)	Application	Method
C-reactive protein (CRP, mg/l)	Inflammation due to injury or infection, acute or chronic response to stress	Minimum 250UL of blood were collected from the middle finger on the non-dominant hand, or if not available, the middle finger on the dominant hand. CRP values were assayed using an enzyme-linked immunosorbent assay protocol (McDade et al., 2004). The Roche Unimate immunoassay and Cobas Inegra Analyzer were used for HbA1c values.
Glycosylated Haemoglobin (HbA1c, mmol/mol*)*	Blood sugar regulation	
Dehydroepiandrosterone (DHEA, μmol/l*)*	Adrenal gland steroid	2 mL of saliva provided using a small chewable sponge. Results were based on an average of two laboratory tests. Identical enzyme immunoassays were used for DHEA values.
Systolic blood pressure (sBP. mmHg*)*	Indices of cardiovascular activity	The mean of two digital blood pressure monitor readings. A one-minute period was left between the first and second reading.
Diastolic blood pressure (dBP, mmHg*)*		
*Pulse (*beats per minute)		
Body Mass Index (BMI, kg/m^2*)*	Indices of anthropometric functioning	Scales switched to pounds, and measuring tape for height (recorded to the nearest half inch).
Waist Circumference (inches)		Measuring tape around the narrowest part of the torso just above the navel.

in the last 12 months, (2) infrequent sexual touch, and (3) frequent sexual touch. These categories were derived based on responses to two questions. The first question was "had sex in the last year?" which had responses of yes or no. For respondents who answered yes, a second question was used "when you had sex with your partner in the last 12 months, how often did your activities include kissing, hugging, caressing, or other ways of sexual touching?" Respondents provided ratings on a 5-point scale from 1 (never) to 5 (always). Individuals who reported always sharing sexual touching during their sexual encounters were categorised as having 'frequent' sexual touch, while all other groups were combined and categorised as having 'infrequent' sexual touch.

2.4.2. Alcohol Intake

Three variables measured alcohol intake: "Have you ever drunk alcohol?", "Do you drink alcohol?", and "How many days per week do you drink?" This was a categorical variables with three groups: (1) regular drinkers (respondents who drink alcohol at least one day per week); (2) non-regular drinkers (respondents who drink alcohol less than one day a week), and (3) never drank alcohol.

2.4.3. Household Composition

Number of co-residents was as a categorical variable with three groups including (1) lives alone, (2) lives with one other person, and (3) lives with two or more persons.

2.4.4. Romantic Partner

The romantic partner variable was treated as a binary variable for those who do have a romantic partner (married, living with a partner, or has a romantic, intimate, or sexual partner) and those who do not (separated, divorced, widowed, never married, and does not have a romantic, intimate or sexual partner).

2.5. Sociodemographic characteristics

Sex and ethnicity were measured as binary variables (men and women; white and non-white (black and Hispanic respondents)). Respondent's age was categorised into three groups: (1) 57–64, (2) 65–74, and (3) 75–85 years. Social economic position (SEP) combined two variables; total household assets (property, cars, businesses, financial assets etc.) and educational attainment. Educational attainment was measured as a categorical variable with four groups, including (1) less than high school, (2) high school degree or equivalent, (3) some college or associate degree, and (4) bachelor's degree or higher. Total household assets was also a categorical variable with four groups: (1) $0–49,999, (2) $50,000–99,999, (3) $100,000–499,999, and (4) $500,000 or more.

2.6. Statistical analyses

PCA empirically determined the underlying dimensions associated with the biomarkers commonly used to construct AL. While the original AL model used a single score, research that is more recent has suggested that a multiple-component model might explain more of the variance in AL (McCaffery et al., 2012). Analysing the eigenvalues, scree plots, and components loadings for each of the eight biomarkers provided the basis for deciding how many underlying components to retain. The identified components were the outcome variables, representing metabolic, cardiovascular, and neuroendocrine health. To describe respondent characteristics of touch frequency by demographic characteristics and covariates, we used cross-tabulations and Chi-Square Test of Independence with Benjamini-Hochberg correction for multiple comparisons.

Following recommendation (O'Muircheartaigh et al., 2009), the original data were weighted using a probability weight, accounting also for the multi-stage sampling design, and adjusted for nonresponse. Multiple imputation using chained equations (MICE) with 20 imputations (White et al., 2011) addressed missing data (assumed to be missing at random), with the intention of avoiding loss of data and statistical power. We imputed all variables except for the outcome variables. Further analyses used the multiple imputed data based on 1419 cases. Imputation models included NSHAP survey weights.

Next, linear regression models adjusted for sociodemographic characteristics (age, sex, ethnicity and SEP) were used to examine the association between the three outcome component loads in separate models (metabolic, cardiovascular and neuroendocrine) with each covariate. Last, multiple regression tested the association between touch frequency separately from romantic partners and other close adults and each component load following stepwise adjustment for a series of covariates; household composition, romantic partner (only for the touch frequency with other close adults models), sexual touch and alcohol intake. We conducted the statistical analyses using STATA 14.1 (StataCorp. 2015. Stata Statistical Software: Release 14.1. College Station, TX: StataCorp LP).

3. Results

3.1. Participant characteristics

Table 2 shows the relationship between touch frequency (from partners and other adults), sociodemographic variables and covariates in NSHAP wave 1. To account for multiple comparisons, the Benjamini-Hochberg correction was applied to the p-values obtained from chi-square tests. The results reported remained statistically significant after adjustment. More frequent touch with romantic partners was reported by white respondents ($X^2(3) = 33.63$, $p < .001$), the most educated ($X^2(9) = 27.55$, $p = 0.001$), those who shared more sexual touch ($X^2(6) = 109.58$, $p < .001$) and respondents who reported

Table 2
Descriptive statistics of touch frequency by demographic characteristics and covariates in Wave 1 (2005–06) of the NSHAP.

Variables	N =	Partner Touch Frequency (%)				N =	Touch with Others Frequency (%)			
		Yearly or Less	Monthly	Weekly	>Weekly		Yearly or Less	Monthly	Weekly	>Weekly
Sex	**878**					**878**				
Women[a]		46.48	30.00	38.55	36.09		39.80	53.33	58.78	59.54
Ethnicity	**859**					**1278**				
White[b]		64.71	60.42	72.50	84.62		74.49	84.38	77.01	71.09
Age (y)	**878**					**1309**				
57–64		28.99	46.00	34.94	40.09		32.50	32.73	32.26	34.73
65–74		37.68	36.00	42.17	38.61		37.81	40.00	36.92	40.08
75–85		33.33	18.00	22.89	21.30		29.68	27.27	30.82	25.19
Educational Attainment	**878**					**1309**				
<High School		30.43	28.00	18.07	13.76		22.06	15.15	18.28	24.81
High School Degree or Equivalent		31.88	28.00	31.33	26.04		31.34	21.21	24.01	23.28
Some College or Associate Degree		26.09	24.00	22.89	31.80		26.87	30.91	32.62	28.24
Bachelor's Degree or Higher		11.59	20.00	27.71	28.40		19.73	32.73	25.09	23.66
Total Household Assets ($)	**628**					**925**				
0–49,999		15.69	15.38	13.56	10.44		19.86	15.08	14.43	26.20
50,000–99,999		11.76	17.95	6.78	8.98		12.44	9.52	12.37	11.76
100,000–499,999		45.10	41.03	40.68	40.50		39.00	43.65	41.24	36.36
500k or higher		27.45	25.64	38.98	40.08		28.71	31.75	31.96	25.67
Number of co-residents	**877**					**1306**				
Lives alone		4.35	12.00	7.23	5.63		24.75	29.70	28.06	27.20
Lives with one other person		73.91	60.00	69.88	75.26		54.98	51.52	55.40	48.28
Lives with two or more persons		21.74	28.00	22.89	19.11		20.27	18.79	16.55	24.52
Romantic Partner						**1309**				
Yes[c]							68.82	66.06	67.03	64.50
Frequency of Sexual Touch	**842**					**1265**				
No Sex		70.15	29.79	41.56	23.81		51.56	46.25	48.18	51.78
Infrequent Sexual Touch		16.42	34.04	22.08	11.06		11.07	13.12	7.66	9.88
Frequent Sexual Touch		13.43	36.17	36.36	65.13		37.37	40.62	44.16	38.34
Alcohol Intake	**646**					**952**				
Never Drank		22.00	25.71	10.61	13.13		21.38	12.03	18.06	23.63
Non-Regular Drinker		26.00	17.14	34.85	23.84		27.55	20.30	25.93	23.08
Regular Drinker		52.00	57.14	54.55	63.03		51.07	67.67	56.02	53.30
Touch with others	**874**									
Yearly or Less		78.26	70.83	42.17	43.03					
Monthly		5.80	20.83	18.07	11.72					
Weekly		8.70	8.33	25.30	23.00					
>Weekly		7.25	0.00	14.46	22.26					

Note. These descriptive statistics were produced prior to the imputation of missing values for all variables except the biomarkers used as the outcome variables. Descriptive statistics were computed for each comparison separately, resulting in varying sample sizes due to missing data on the exposure variables and covariates.
[a] Compared to men
[b] Compared to non-white respondents
[c] Compared to no romantic partner available

infrequent touch with other close adults ($X^2(9) = 59.46$, $p < .001$). More frequent touch with other close adults was reported by women ($X^2(3) = 43.85$, $p < .001$), white respondents ($X^2(3) = 10.18$, $p = 0.017$), and those with some college or associate degree ($X^2(9) = 26.82$, $p = 0.001$).

3.2. Data reduction: Principle component analysis of biomarkers

PCA with oblique rotation uncovered the number of components among eight AL markers. Three components had eigenvalues greater than 1, a common rule of thumb for determining the number of components to retain (Costello and Osborne, 2005). A scree plot graphically represented this (see Appendices Figure A.1). The component loadings for the total sample range from − 0.49–0.89 (see Appendices Table A.2). Most strongly correlated with the underlying component for metabolic health were BMI (0.89), waist circumference (0.89), log transformed CRP (0.49), and HbA1c (0.47). Most strongly correlated with the underlying component for cardiovascular health were systolic blood pressure (0.88) and diastolic blood pressure (0.87). Most strongly correlated with the underlying component for neuroendocrine health were pulse (0.82) and DHEA (−0.49).

3.3. Relationship of components of AL and covariates

Linear regression models were performed to examine the associations between covariates and each component load, including metabolic, cardiovascular and neuroendocrine health, serving as outcome variables (see Table 3). The results revealed significant associations between higher educational attainment, greater total household assets and increased engagement in sexual touch with better metabolic health. Conversely, reduced alcohol intake and an increased household number were associated with worse metabolic health.

Regarding cardiovascular health, a significant association was observed with romantic partner availability. Respondents who reported having a romantic partner exhibited better cardiovascular health compared to those without a romantic partner. Furthermore, better neuroendocrine health was significantly associated with greater total household assets, and increased engagement in sexual touch. Conversely, worse neuroendocrine health was significantly associated with living alone.

3.4. Relationship of components of AL and touch

Multiple regression by stepwise adjustment models built on each base model (adjusted for sociodemographic characteristics: age, sex,

Table 3
Associations between covariates and metabolic, cardiovascular and neuroendocrine health, adjusted for age, sex and ethnicity (N = 1419).

Covariates	Outcome Variables					
	Metabolic Health		Cardiovascular Health		Neuroendocrine Health	
	Estimates	95% CI	Estimates	95% CI	Estimates	95% CI
Educational Attainment[a]						
< High School Degree	0.08	-0.09 – 0.25	-0.05	-0.20 – 0.09	0.12	-0.13 – 0.36
High School Degree or Equivalent	0.05	-0.09 – 0.19	0.00	-0.13 – 0.13	0.04	-0.16 – 0.24
Bachelor's Degree or Higher	-0.22 * *	-0.36 – – 0.07	-0.02	-0.20 – 0.16	-0.19	-0.42 – 0.03
Total Household Assets[b]						
$0-$49,999	0.09	-0.18 – 0.36	0.06	-0.15 – 0.27	0.30 *	0.08 – 0.53
$50,000-$99,999	0.16	-0.12 – 0.44	0.03	-0.29 – 0.35	0.22	-0.09 – 0.53
$500k or higher	-0.25 * *	-0.43 – – 0.08	-0.02	-0.20 – 0.16	-0.21 *	-0.41 – – 0.00
Sexual Touch[c]						
Infrequent Sexual Touch	-0.15	-0.40 – 0.11	0.07	-0.15 – 0.30	-0.07	-0.31 – 0.18
Frequent Sexual Touch	-0.30 * *	-0.46 – – 0.14	-0.04	-0.21 – 0.13	-0.23 * *	-0.39 – – 0.08
Alcohol Intake[d]						
Non-Regular Drinkers	0.30 * *	0.14 – 0.47	-0.01	-0.20 – 0.18	-0.02	-0.22 – 0.18
Never Drank Alcohol	0.35 * *	0.15 – 0.56	-0.08	-0.28 – 0.12	0.04	-0.17 – 0.26
Household Composition[e]						
Lives Alone	0.00	-0.20 – 0.20	0.15	-0.01 – 0.32	0.22 *	0.03 – 0.42
Lives with Two or More Persons	0.25 * *	0.07 – 0.43	-0.01	-0.19 – 0.17	0.02	-0.16 – 0.21
Romantic Partner[f]						
No	0.14	-0.01 – 0.30	0.22 * *	0.07 – 0.37	0.15	-0.01 – 0.30

Note. Reference categories were chosen based on largest group.
[a] Educational Attainment reference category is 'Some College or Associate Degree'.
[b] Total Household Assets reference category is '$100,000 - $499,999'.
[c] Sexual Touch reference category is 'No Sex in the Last 12 Months'.
[d] Alcohol Intake reference category is 'Regular Drinkers'.
[e] Household Composition reference category is 'Lives with One Other Person'.
[f] Romantic Partner reference category is 'Yes'.
$^{*}p < .05$. $^{**}p < .01$.

ethnicity and SEP), with covariates added incrementally. Regarding the relationship between touch frequency and metabolic health, no significant associations were found (see Table 4 and Appendices Figure A.2). Similarly, no significant association was found between touch frequency and cardiovascular health (see Table 4 and Appendices Figure A.3). However, in the case of neuroendocrine health, analyses revealed a significant relationship with romantic partner touch frequency. The findings indicated that a one-unit increase in touch frequency with romantic partners resulted in a 0.13 standard deviation increase in the neuroendocrine health component loading (see Table 4 and Fig. 1). This association remained robust to adjustment with all covariates examined, with only minimal changes to the regression coefficient occurring beyond the second decimal place. On the other hand, the relationship between touch frequency with close others and neuroendocrine health was found to be non-significant. The general trend suggested better neuroendocrine health as the frequency of touch with close other adults decreased (see Fig. 1).

4. Discussion

This study explored the relationship between frequency of interpersonal touch and components of AL in older adults, with the additional objective of examining whether touch exchanged with romantic partners differed in its associations from touch shared with other close individuals. We hypothesised that respondents who reported more frequent physical touch would have lower AL compared to those with less frequent touch, and that this relationship would be more robust for touch with romantic partners as compared to other close adults. Our findings suggest that the AL construct is not homogeneous. Our findings also provide the first evidence that touch frequency with romantic partners is associated with neuroendocrine health in older adults. Specifically, individuals who reported sharing touch with their romantic partners more frequently exhibited better neuroendocrine health compared to those who shared touch infrequently with partners. No benefits were observed for respondents who reported frequent touch with other close adults. Our findings align with prior studies indicating that physical touch may have protective effects against various stress-related outcomes in laboratory settings, including lower cortisol levels in humans (Ditzen et al., 2007).

Moreover, our results support the notion that the benefits of touch are more pronounced in romantic partnerships (Coan et al., 2006). This is consistent with previous research supporting the enduring advantages of touch with romantic partners in mitigating stress and improving physiological well-being. These studies have shown that even brief physical contact with romantic partners can lead to immediate and prolonged benefits, such as reduced blood pressure and heart rate reactivity (Grewen et al., 2003; Triscoli et al., 2017). While previous research has established that touch with romantic partners can reduce acute stress and improve health, our study makes a unique contribution by uncovering the potential of frequent touch with romantic partners specifically for cultivating neuroendocrine health in older adults. This interplay between partner touch, neuroendocrine regulation, and stress management contributes to a deeper understanding of the therapeutic potential of touch in older adult populations.

This study used eight AL markers; CRP, HbA1C, DHEA, sBP, dBP, pulse, BMI, and waist circumference. As previously mentioned, high AL is often associated with poor cognitive and physical functioning (Karlamangla et al., 2002), cardiovascular disease (Seeman et al., 2001) and all-cause mortality (Goldman et al., 2006). There is currently no consensus on the number and range of biomarkers to measure AL effectively. Mauss et al. (2015) found in a systematic review that 39 different biomarkers, ranging between six and 17 measures per study had been used. Although evidence suggests that diversity of biomarkers used to measure AL is not problematic (Juster et al., 2010). A recent meta-analysis (McCrory et al., 2023) identified a panel of five specific AL markers that consistently exhibit associations with health and mortality. These markers, namely CRP, heart rate, high density lipoprotein cholesterol (HDL), waist-to hip-ratio, and HbA1c, have been recommend by the authors for inclusion in future studies to facilitate comparisons of cumulative physiological burden across various socio-demographic

Table 4
The relationship between touch frequency from partners or other close adults and each component load (N = 1419).

	Covariates sequentially added to base models	Partner touch frequency	Close other adult touch frequency
Metabolic Health			
Model 1	Base model	β = 0.01, p = 0.849	β = 0.01, p = 0.508
Model 1 +	Household composition (model 2)	β = 0.01, p = 0.650	β = 0.01, p = 0.531
Model 2 +	Romantic partner availability (model 3)		β = 0.01, p = 0.553
Model 3 +	Sexual touch (model 4)	β = −0.02, p = 0.648	β = 0.01, p = 0.709
Model 4 +	Alcohol intake (model 5)	β = −0.02, p = 0.645	β = 0.00, p = 0.932
Cardiovascular Health			
Model 1	Base model	β = −0.06, p = 0.144	β = 0.02, p = 0.337
Model 1 +	Household composition (model 2)	β = −0.07, p = 0.117	β = 0.02, p = 0.330
Model 2 +	Romantic partner availability (model 3)		β = 0.02, p = 0.344
Model 3 +	Sexual touch (model 4)	β = −0.08, p = 0.097	β = 0.02, p = 0.305
Model 4 +	Alcohol intake (model 5)	β = −0.08, p = 0.097	β = 0.02, p = 0.266
Neuroendocrine Health			
Model 1	Base model	**β = 0.13, p = 0.002**	β = −0.01, p = 0.585
Model 1 +	Household composition (model 2)	**β = 0.13, p = 0.002**	β = −0.01, p = 0.594
Model 2 +	Romantic partner availability (model 3)		β = −0.01, p = 0.598
Model 3 +	Sexual touch (model 4)	**β = 0.13, p = 0.004**	β = −0.02, p = 0.506
Model 4 +	Alcohol intake (model 5)	**β = 0.13, p = 0.004**	β = −0.02, p = 0.541

Note. The base model estimates the relationship between each outcome load (metabolic, cardiovascular and neuroendocrine) and touch frequency, separately for partners and other close adults, and are adjusted for sociodemographic characteristics (age, sex, ethnicity and SEP).

groups and age ranges. Although our study encompasses four out of these five core markers, it is worth noting that the results might have differed if HDL had been included. The inclusion of HDL in future investigations would provide a more complete assessment of touch frequency and its implications for health outcomes.

We used PCA to investigate whether the biological markers measured in the NSHAP can be operationalised to assess AL and whether they function as a single construct or multiple systems. PCA identified that AL loads onto three individual system components (metabolic, cardiovascular and neuroendocrine health), as seen in previous literature (McCaffery et al., 2012). In our analyses, we classified the factor showing high loadings for DHEA and pulse as 'neuroendocrine'. DHEAS is produced by the adrenal glands (Suzuki et al., 1991), while pulse is an indicator of vagal function (Porges, 2007). DHEA and its metabolites have immune-enhancing properties (Suzuki et al., 1991), which are important for the stress response system and include anti-inflammatory and anti-glucocorticoid effects. DHEA also stimulates the secretion of catecholamine's, playing a key role in regulating the HPA axis (Maninger et al., 2009). DHEAS, the blood-borne form of DHEA, is widely recognised as one of the key neuroendocrine markers for a reasonably constructed AL.

Ideally, we would have used heart rate variability (HRV) to assess autonomic nervous system regulation. HRV provides insights into the activity of both the sympathetic and parasympathetic nervous systems, which can be influenced by the HPA axis (Bigger et al., 1993). However, HRV was not available in the NSHAP dataset. In this sample, pulse and DHEA were most strongly correlated to the neuroendocrine load component, as such; pulse may be acting as a substitute of HRV, and representing autonomic balance (Thayer and Brosschot, 2005). Future studies should consider incorporating direct HRV measurements to obtain a more comprehensive understanding of autonomic nervous system regulation in relation to the HPA axis.

Our results indicate that touch with partners has greater salience to neuroendocrine health than touch with others. Romantic partners often develop a stronger emotional connection, which could lead to heightened positive emotional experiences during physical touch. Positive emotional experiences, including touch have been shown to stimulate the release of hormones, such as oxytocin, that have positive effects on neuroendocrine health (Holt-Lunstad et al., 2008; Uvnäs Moberg et al., 2020). Secondly, touch between romantic partners tends to be more intimate and varied compared to touch with other close adults. For instance, touch between romantic partners tends to be more frequent (Heslin and Alper, 1983; Suvilehto et al., 2019; Sorokowska et al., 2021) and sustained compared to touch with other close adults, and may involve more kissing, hugging, and sexual touch, which can elicit a broader range of physical sensations and emotions. Duration of and variety in touch experiences may lead to more positive emotions and greater and more consistent stimulation of hormones that promote neuroendocrine health (Light et al., 2005). Future studies could

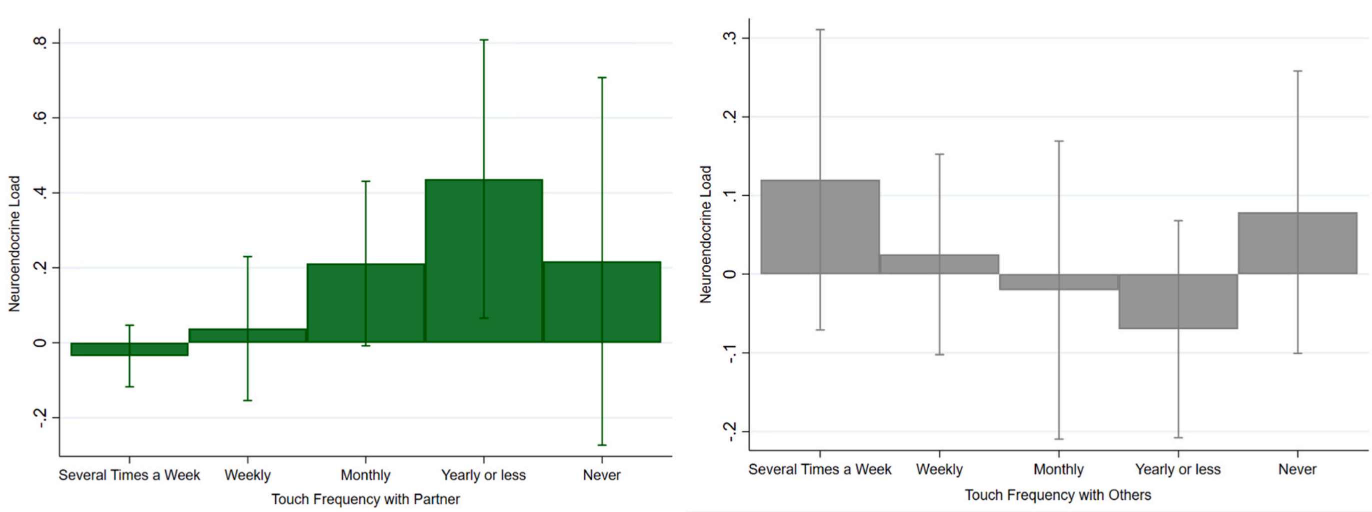

Fig. 1. Mean neuroendocrine health by decreasing touch frequency by partner (left) and others (right). Note. More positive neuroendocrine load scores indicate worse neuroendocrine health. Lines represent 95% confidence intervals.

substantiate this speculation by measuring hormonal secretion from romantic partners touch as compared to touch with other adults directly.

The association of romantic partner touch and neuroendocrine health was robust to the adjustment of a wide range of covariates. Of the covariates examined, we saw that respondents with a romantic partner exhibited better cardiovascular health compared to those without a romantic partner. This suggests that the mere presence of a romantic partner has protective effects on cardiovascular health. Covariate associations also revealed that worse metabolic health was also associated with increased household size, whilst living alone was associated with worse neuroendocrine health, in line with existing literature showing that household composition can affect health (Henning-Smith et al., 2016). Improved metabolic and neuroendocrine health were associated with greater total household assets and frequent affective touch during sexual intercourse. Previous studies have demonstrated that physical affection and sexual activity are linked to reduced same-day negative moods and stress (Burleson et al., 2007). This may be attributed to the enhanced release of oxytocin associated with both touch and sexual activity (Carmichael et al., 1987; Lund et al., 2002). Consequently, it would be valuable for future studies to carefully examine and isolate the effects of sexual and non-sexual touch frequency.

In this study, no effects emerged of touch frequency with close adults on metabolic, cardiovascular and neuroendocrine health. There were also no effects of touch frequency with romantic partners on metabolic and cardiovascular health. These results contradict existing literature that suggests a positive association between touch-based interventions and cardiovascular health and stress reduction (Hou et al., 2010), which suggests that touch may indirectly improve metabolic health. The lack of association found in our study may be attributed to the limitations of the NSHAP touch questions, which did not capture the type or context of the touch reported by respondents. For example, kissing on the lips and hugging (Gulledge et al., 2003) are rated as more expressive of love than backrubs and massages. As the NSHAP touch questions did not encompass these distinctions, they should be investigated in future studies on touch as a stress co-regulatory mechanism in older adults. Stress can also be harmful in romantic relationships, and heightened metabolic and/or cardiovascular stress may impair a romantic relationship, which could make touch between partners less pleasant (Randall and Bodenmann, 2009). Future research should therefore also investigate the impact of relationship quality on the association between touch and metabolic and cardiovascular health.

The advantages and limitations of this study require discussion. This is a large study of older men and women, examining several confounders and mediators. Analyses were based on data limited to a subset of participants who had no missing values for all eight biomarkers used as outcome variables. Although there were minor variations between the analytic sample and the non-analytic sample across different sociodemographic characteristics and covariates, the differences were generally not substantial (refer to Appendices Table A.1). Secondly, analyses were cross-sectional, which limits interpretation of the direction of the relationship. One could argue that healthy individuals with a better neuroendocrine health have more opportunities to share touch with their romantic partners, for example. While, several theoretical arguments suggest that touch frequency can benefit chronic stress in the direction of causality we suggest (Field, 2010; Holt-Lunstad et al., 2015), future research would benefit from examining the bidirectional links between touch frequency with romantic partners and neuroendocrine health over time. Additionally, social desirability bias may have influenced subjective self-reported measures of physical touch. While NSHAP is the only nationally representative dataset of older adults to include questions about non-sexual touch from different close resources, the questions and response choices are vague and retrospective. Further research would benefit from direct investigation of the duration, quality, and types of touch (sexual or non-sexual, goal-directed or spontaneous) and their effects on AL. Similarly, future studies should explore how touch with strangers or less close acquaintances affects AL.

In summary, our study has revealed for the first time associations indicating that physical touch plays a role in the health-promoting effects of romantic relationships among older adults, surpassing relationships with other close adults. Our findings suggest that physical touch between romantic partners is linked to a reduction in the burden on the neuroendocrine system, encompassing hormonal and physiological stress responses. Specifically, it suggests that such touch is associated with a decrease in the release of stress-related hormones like DHEA. These observed benefits could potentially be mediated by central nervous neuroendocrine systems (e.g., oxytocin and opioids), which help dampen the stress response of the HPA axis and ANS during stressful situations (Heinrichs et al., 2003). Considering the expected significant increase in the global older adult population in the coming decades, these findings underscore the importance of fostering physical touch within romantic partnerships as a means to support the well-being and health of the growing ageing population.

CRediT authorship contribution statement

Gabriele Navyte: Conceptualization, Methodology, Software, Formal Analysis, Data Curation, Writing – Original Draft, Visualization. **Helge Gillmeister:** Writing – Review & Editing, Supervision. **Meena Kumari:** Conceptualization, Methodology, Writing – Review & Editing, Visualization, Supervision.

Declaration of Competing Interest

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Appendices

Table A.1
Descriptive statistics of respondents in the analytic sample versus those not in the analytic sample by sociodemographic characteristics and covariates.

Sociodemographic characteristics and covariates	Present in analytic sample (n = 1419) Frequency (%)	Not present in analytic sample (n = 1586) Frequency (%)
Sex		
Men	**51.02**	**46.03**
Women	**48.98**	**53.97**
Age		
57–64	**32.49**	**35.25**
65–74	**38.34**	**34.55**
75–85	**29.18**	**30.20**
Educational Attainment		
< High school degree	**22.20**	**24.21**

(*continued on next page*)

Table A.1 (*continued*)

Sociodemographic characteristics and covariates	Present in analytic sample (n = 1419) Frequency (%)	Not present in analytic sample (n = 1586) Frequency (%)
High school degree or equivalent	**26.71**	**26.10**
Some college or associate degree	**28.19**	**28.75**
Bachelor's degree or higher	**22.90**	**20.93**
Total Household Assets		
0–49,999	**20.50**	**24.13**
50,000–99,999	**11.86**	**8.74**
100,000–499,999	**39.20**	**37.18**
500k or higher	**28.44**	**29.95**
Ethnicity		
White	**74.58**	**70.03**
Non-White	**25.42**	**29.97**
Romantic Partner		
Yes	**66.53**	**67.40**
No	**33.47**	**32.60**
Number of co-residents		
Lives alone	**27.05**	**28.90**
Lives with one other person	**51.98**	**49.84**
Lives with two or more persons	**20.97**	**21.26**
Frequency of Sexual Touch		
No sex	**50.73**	**50.82**
Infrequent sexual touch	**10.45**	**12.11**
Frequent sexual touch	**38.82**	**37.07**
Alcohol Intake		
Regular drinkers	**54.86**	**48.97**
Non-regular drinkers	**24.71**	**26.12**
Never drank alcohol	**20.43**	**24.91**
Frequency of Touch with Partner		
>Weekly	**76.99**	**76.38**
Weekly	**9.45**	**12.07**
Monthly	**5.69**	**4.60**
Yearly or less	**7.86**	**6.95**
Frequency of Touch with Others		
>Weekly	**20.02**	**22.12**
Weekly	**21.31**	**19.30**
Monthly	**12.61**	**11.99**
Yearly or less	**46.07**	**46.59**

Note. All those not in the analytic sample had missing values for at least one of the eight biomarkers used as outcome variables.

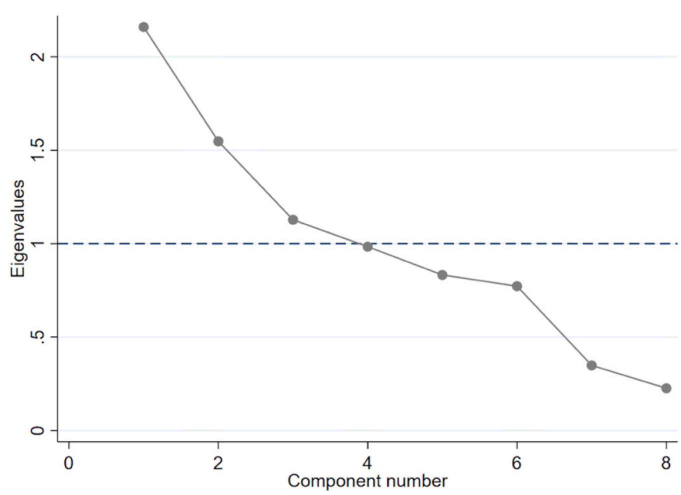

Figure A.1. . Scree plot showing the eigenvalues for each individual component.

Table A.2
Weighted component loadings for each biomarker for the full sample.

Biomarker	Metabolic Health	Cardiovascular Health	Neuroendocrine Health
BMI (kg/m^2)	0.89	0.13	-0.16
Waist Circumference (inches)	0.89	0.12	-0.20
CRP (log transformed) (mg/L)	0.49	-0.02	0.34
HBa1C (percent of total haemoglobin)	0.47	-0.17	0.14
Systolic Blood Pressure (mm Hg)	0.01	0.88	-0.07
Diastolic Blood Pressure (mm Hg)	0.06	0.87	0.22
Pulse (beats/min)	0.08	-0.04	0.82
DHEA (pg/mL)	0.09	-0.09	-0.49

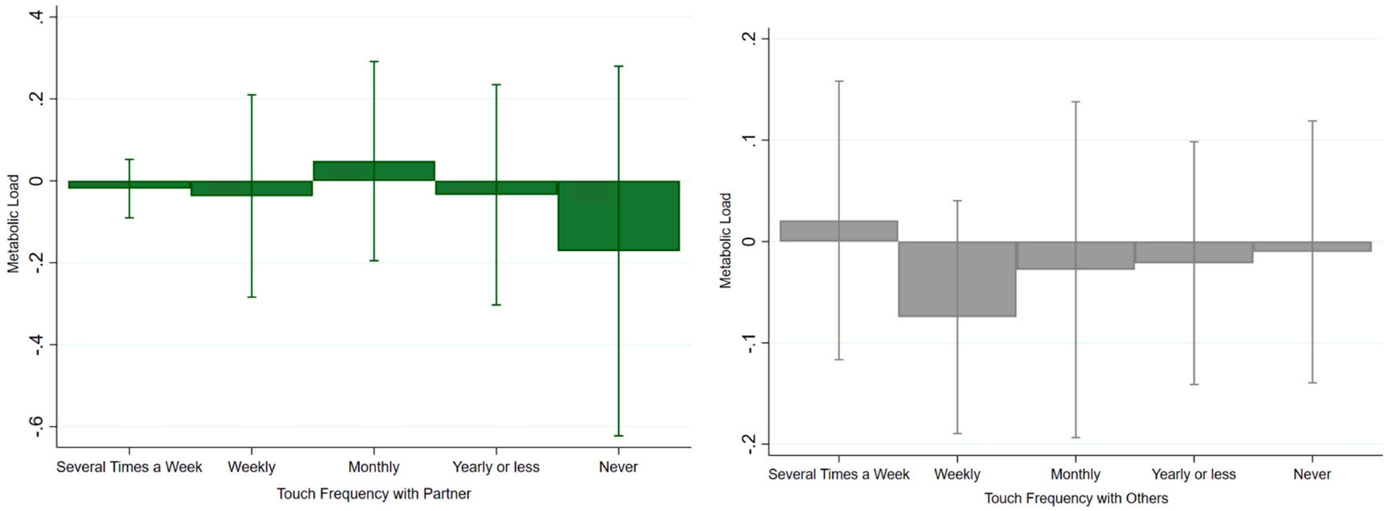

Figure A.2. . No association of metabolic health and partner touch frequency (left) and other close adult touch frequency (right). Note. More positive metabolic load scores indicate worse metabolic health. Lines represent 95% confidence intervals.

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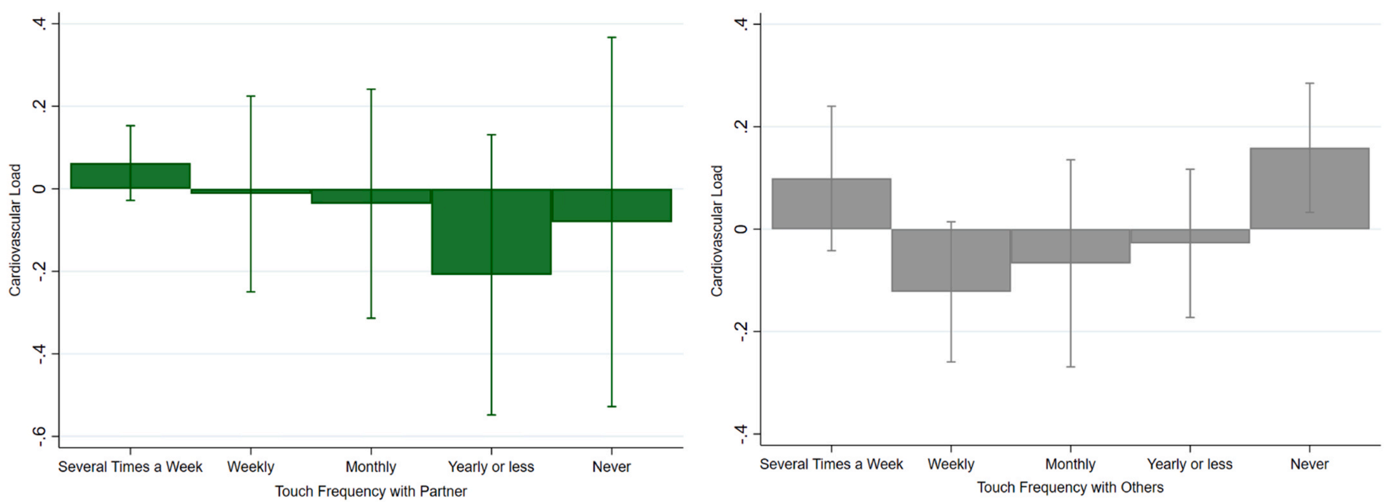

Figure A.3. . No association of cardiovascular health and partner touch frequency (left) and other close adult touch frequency (right). Note. More positive cardiovascular load scores indicates worse cardiovascular health. Lines represent 95% confidence intervals.

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