Scandinavian Journal of Psychology, 2024, 65, 1101–1112 DOI: 10.1111/sjop.13052

Empirical Article

Associations of lipids in adolescence and adulthood with self- and other-directed compassion in adulthood

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Pihlaja, S., Jääskeläinen, E., Heikkilä, L. & Hintsanen, M. (2024). Associations of lipids in adolescence and adulthood with self- and other-directed compassion in adulthood. *Scandinavian Journal of Psychology*, *65*, 1101–1112.

Self- and other-directed compassion have been linked with better mental and physical health but research on factors contributing to their development is scarce. Previous studies indicate a possible causal relationship of lipids with personality and socioemotional functioning. As an extension to earlier research, in the present study we examine whether lipids assessed in adolescence and adulthood are associated with self-compassion and other-directed compassion in adulthood. The study utilizes data on lipids from two follow-ups in the Northern Finland Birth Cohort 1986 at ages 15–16 and 33–35. In the latter follow-up also self-compassion and other-directed compassion were assessed with the self-compassion scale – short form and the subscale for compassion in the dispositional positive emotions scale, respectively. The sample for the cross-sectional associations of lipids in adulthood with the compassion variables in adulthood includes 1,459 participants, whereas the sample for the longitudinal associations of lipids in adolescence and the compassion variables in adulthood consists of 1,509 participants. The associations were examined with hierarchical linear regression (lipids as continuous variables) and univariate general linear model (lipids as categorical variables). The results suggest that in women, high-density lipoprotein (HDL) cholesterol in adolescence is associated with high empathic concern (a component of other-directed compassion) in adulthood. The results show further that, in women, an HDL cholesterol level above 1.2 mmol/L in adulthood is associated with high other-directed compassion and empathic concern in adulthood. The present study provides tentative evidence that biological factors such as lipids might play a role in the development of empathic concern and other-directed compassion.

Key words: compassion, empathic concern, lipids, other-directed compassion, self-compassion.

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INTRODUCTION

Self-compassion refers to an open-minded, kind and non-judgmental attitude towards one's own distress, flaws and failures without overidentifying with them or trying to avoid them (Neff, 2003). It also includes the idea of suffering as part of common humanity. Other-directed compassion, in turn, is defined as the ability to observe others' suffering, the concern it arouses and the willingness to alleviate the suffering (Goetz, Keltner & Simon-Thomas, 2010). Empathic concern is closely related to other-directed compassion and refers to an emotional reaction caused by and directed at others' suffering (Batson, Lishner & Stocks, 2015; Davis, 1980). It is comparable to the affective component of other-directed compassion, that is, the concern for others' suffering (Roeser, Colaianne & Greenberg, 2018). Although originally defined as an attitude towards oneself (Neff, 2003), self-compassion can be regarded both as a state and a trait and, recently, self-compassion has been increasingly treated as a trait (Neff, 2023). Other-directed compassion can, as well, be regarded as a state (an emotion) and a trait (a tendency to feel that emotion) and they are both thought to have an evolutionary basis (Goetz *et al*., 2010). In this study, self-compassion, other-directed compassion and empathic concern are regarded as traits that are relatively stable but that can also be enhanced through learning (Mascaro, Florian, Ash, *et al*., 2020; Neff, 2023). Whereas self-compassion has been linked to characteristics like emotional stability (Arslan, 2016; Neff, Rude & Kirkpatrick, 2007) and optimism (Neff *et al*., 2007), other-directed compassion has been linked to traits such as openness, humility, emotionality, conscientiousness and agreeableness (Addiss, Richards & Adiabu, 2022).

As recent research has shown, self-compassion and other-directed compassion are associated with higher well-being (Saarinen, Keltikangas-Järvinen, Pulkki-Råback, *et al*., 2020; Zessin, Dickhäuser & Garbade, 2015) and mental (Inwood & Ferrari, 2018; Macbeth & Gumley, 2012; Saarinen, Keltikangas-Järvinen, Cloninger, *et al*., 2019) and physical health (Phillips & Hine, 2021; Saarinen, Keltikangas-Järvinen, Hintsa, *et al*., 2020). Thus, from a public health perspective, it is important to examine what kind of factors affect the development of self- and other-directed compassion. The present study aims to investigate whether lipids assessed in adolescence and adulthood are associated with self-compassion, other-directed compassion and empathic concern in adulthood. Numerous studies have linked blood lipid levels to psychopathology, such as aggression (Gajos & Beaver, 2016; Hillbrand & Spitz, 1999) and depression (Bazinet & Layé, 2014; Wu *et al*., 2016) but little is known about the associations between blood lipids and adaptive psychological functioning, such as self-compassion and other-directed compassion. Potential lipids in terms of compassion are, for

example, cholesterol, triglycerides and polyunsaturated fatty acids. Lipids, in general, cover a variety of water-insoluble hydrocarbon molecules (Subramaniam, Fahy, Gupta, *et al.*, 2011). The lipids included in this study participate in transferring and storing energy and regulating cellular functions (Appleton, Rogers & Ness, 2008; Brown, 2007; Cartocci, Servadio, Trezza & Pallottini, 2017).

Currently, not much is known about the factors contributing to the development of self-compassion and other-directed compassion. However, a growing body of literature suggests that the roots of self-compassion and other-directed compassion lie in childhood: several childhood factors related to parenting and social environment have been found to be associated with self-compassion and other-directed compassion (Bluth, Park & Lathren, 2020; Gluschkoff, Oksman, Knafo-Noam, *et al.*, 2018; Hintsanen, Gluschkoff, Dobewall, *et al.*, 2019; Pepping, Davis, O'Donovan & Pal, 2015; Saarinen, Keltner, Dobewall, Lehtimäki, Keltikangas-Järvinen & Hintsanen, 2021; Zhang, Li, Sun & Wei, 2023). For example, childhood maltreatment has been associated with low self-compassion (Zhang *et al.*, 2023), whereas parental warmth has been found to predict higher other-directed compassion more than three decades later in offspring as adults (Hintsanen *et al.*, 2019). So far, there has mainly been research on the psychosocial factors associated with the development of self-compassion and other-directed compassion but the effect of biological factors may also be important. Lipids (Bazinet & Layé, 2014; Cartocci *et al.*, 2017; Van De Rest, Van Hooijdonk, Doets, Schiepers, Eilander & De Groot, 2012; Zhang & Liu, 2015) have a significant role in the development and functioning of the central nervous system and, consequently, might affect personality as well. For instance, lipids might affect the activity of the neurotransmitters (e.g., serotonin, dopamine, oxytocin) that have been linked with compassion-related phenomena (Keum & Shin, 2019). The associations of lipids with self-compassion and other-directed compassion have not been researched to date.

The lipids investigated in this study include cholesterol, triglycerides and polyunsaturated fatty acids (omega-3 and omega-6 fatty acids). Cholesterol is important for cellular membranes (Yang, Kreutzberger, Lee, Kiessling & Tamm, 2016) and is transferred in the blood as lipoproteins, namely low-density lipoprotein (LDL) cholesterol and high-density lipoprotein (HDL) cholesterol. Triglycerides participate in metabolism as they provide energy and transport dietary fat (Pundir & Narang, 2013). Polyunsaturated fatty acids (PUFAs), that is, omega-3 and omega-6 fatty acids (Bazinet & Layé, 2014), are constituents of cell membranes and have an important role in cell membrane structure and function, especially in the brain (Appleton *et al.*, 2008). Omega-3 fatty acids include, for example, alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA), whereas omega-6 fatty acids include linoleic acid (LA), DPA omega-6 and arachidonic acid (AA) (Bazinet & Layé, 2014). Cholesterol (Cartocci *et al.*, 2017; Zhang & Liu, 2015) and PUFAs (Bazinet & Layé, 2014; Van De Rest *et al.*, 2012) participate in neural activity during neurodevelopment as well as in adulthood.

Given the significance of lipids for neurodevelopment (Bazinet & Layé, 2014; Van De Rest *et al.*, 2012; Zhang & Liu, 2015), it is reasonable to assume that they have the potential for modifying personality. Both experimental and longitudinal studies indicate a possible causal relationship between lipids and qualities relevant to compassion. In a cohort study by Manczak and Gotlib (2019), high HDL cholesterol at birth predicted better skills at emotion regulation, self-awareness and interpersonal functioning at age 5, whereas high very low-density lipoprotein (VLDL) and triglycerides were associated with poorer skills. Other-directed compassion requires emotion regulation and social cognition and awareness (Roeser *et al.*, 2018). In another prospective, population-based study, Tomson-Johanson, Kaart, Kiivet, Veidebaum & Harro (2020) found that low total cholesterol and low LDL cholesterol in childhood and adolescence predicted maladaptive impulsivity in early adulthood in men. In addition, omega-3 fatty acids have been shown to decrease both trait aggression (Bègue, Zaalberg, Shankland, *et al.*, 2018; Gajos & Beaver, 2016; Long & Benton, 2013) and aggressive behavior (Choy & Raine, 2018; Gajos & Beaver, 2016) and they have also been linked to lower negative affectivity (Hahn-Holbrook, Fish & Glynn, 2019) and hostility (Iribarren, Markovitz, Jacobs, Schreiner, Daviglus & Hibbeln, 2004). Trait aggression, in turn, has been related to psychopathic traits that are associated with low other-directed compassion (Lee & Gibbons, 2017). Low antisocial traits, such as aggression, have been linked with high affective empathy (Campos, Pasion, Azeredo, *et al.*, 2022; Miller & Eisenberg, 1988), which is closely related to other-directed compassion and can be considered one of its key elements (Roeser *et al.*, 2018).

Cholesterol levels have also been linked to aggression. High total cholesterol, high LDL cholesterol and high HDL cholesterol have all been linked with lower aggression, measured as a trait (Buydens-Branchey, Branchey, Hudson & Fergeson, 2000; Hillbrand & Spitz, 1999; Sahebzamani, D'Aoust, Friedrich, Aiyer, Reis & Kip, 2013; Suneson, Asp, Träskman-Bendz, Westrin, Ambrus & Lindqvist, 2019) or a behavior (Eriksen, Bjørkly, Lockertsen, Færden & Roaldset, 2017; Golomb, Stattin & Mednick, 2000; Herceg, Mimica, Herceg & Puljić, 2022; Kaplan, Shively, Fontenot, *et al.*, 1994; Vilibić, Jukić, Pandžić-Sakoman, Bilić & Milošević, 2014). However, most of the studies examining the associations between cholesterols and aggression have been cross-sectional and conducted with clinical samples, such as patients with personality disorders (Buydens-Branchey *et al.*, 2000), schizophrenia (Herceg *et al.*, 2022) and post-traumatic stress disorder (Vilibić *et al.*, 2014) or psychiatric inpatients with diverse diagnoses (Eriksen *et al.*, 2017; Suneson *et al.*, 2019) and, thus, the associations are yet to be established in the normal population.

Compassion-related phenomena (e.g., empathy, altruism and prosocial behavior; Keum & Shin, 2019) have been linked with the neurotransmitters serotonin, dopamine and oxytocin, which, in turn, have been found to be associated with lipids (e.g., Berland, Montalban, Perrin, *et al.*, 2020; Buydens-Branchey *et al.*, 2000; Jones, Zhen & Reith, 2012; Steegmans, Fekkes, Hoes, Bak, van der Does & Grobbee, 1996). The mechanisms through which lipids may affect neurotransmission are not entirely established but it has been noted that lipids participate in the regulation of neurotransmission (Bazinet & Layé, 2014; Cartocci *et al.*, 2017). Thus, it is possible that lipids affect compassion and other prosocial behavior through neurotransmitters.

The aim of the current study was to investigate whether blood lipids assessed in adolescence and in adulthood are associated with self-compassion, other-directed compassion and empathic concern in adulthood in a general population sample with prospectively collected data. Both cross-sectional and longitudinal analyses are included to examine potential temporal differences in the associations. The cross-sectional and longitudinal analyses can yield distinct information on the impact of lipids: as adolescence is an important stage in neurodevelopment (Arain, Haque, Johal, *et al*., 2013), longitudinal associations could mean that lipids are important for compassion during the development of the central nervous system. Potential cross-sectional associations, in turn, could infer that lipids are important for compassion in real-time. If both longitudinal and cross-sectional associations would be observed, that could be a sign that lipids are important for compassion regardless of the phase of the neurodevelopment. The measurement point in adulthood at age 33–35 is somewhat optimal as the brain has already reached its full volume by then but it has not started to decrease yet (Hedman, van Haren, Schnack, Kahn & Hulshoff Pol, 2012).

In this context, lipids refer to total cholesterol, LDL cholesterol, HDL cholesterol, triglycerides, DHA (one of the omega-3 fatty acids), total omega-3 fatty acids, LA (one of the omega-6 fatty acids) and total omega-6 fatty acids. Whereas aggression can be considered a form of antisocial behavior (Campos *et al*., 2022; Miller & Eisenberg, 1988), other-directed compassion is related to its opposite, prosocial behavior (Goetz *et al*., 2010). As mainly low total cholesterol (Golomb *et al*., 2000; Hillbrand & Spitz, 1999; Kaplan *et al*., 1994; Sahebzamani *et al*., 2013; Vilibić *et al*., 2014), LDL cholesterol (Sahebzamani *et al*., 2013; Suneson *et al*., 2019; Vilibić *et al*., 2014), HDL cholesterol (Buydens-Branchey *et al*., 2000; Eriksen *et al*., 2017) and omega-3 fatty acids (Bègue *et al*., 2018; Fido, Heym, Bloxsom, Hunter, Gregson & Sumich, 2021; Long & Benton, 2013) have been found to associate with higher aggression, we hypothesize that high total cholesterol, LDL cholesterol and HDL cholesterol (assessed in adolescence and adulthood) and DHA and total omega-3 fatty acids (assessed in adolescence) are associated with higher other-directed compassion and empathic concern. No hypotheses concerning the relationships of triglycerides, LA and total omega-6 fatty acids with self-compassion, other-directed compassion and empathic concern nor other hypotheses concerning self-compassion are set due to the lack of previous research in this context. There are sex differences in lipid levels and metabolism, especially regarding cholesterol (Cartocci *et al*., 2017) and many studies examining the associations between cholesterol and personality have found the associations to differ in men and women (e. g. Tomson-Johanson & Harro, 2018; Tomson-Johanson *et al*., 2020). There are also sex differences in self-compassion and other-directed compassion: men have been found to be slightly more self-compassionate than women (Yarnell, Stafford, Neff, Reilly, Knox & Mullarkey, 2015), while women have been found to be more compassionate than men (Addiss *et al*., 2022). Thus, we take potential sex interactions in the studied associations into account. In addition to analyzing lipids as continuous variables, we examine whether cholesterol and triglyceride levels outside the recommended ranges (Piepoli, Hoes, Agewall *et al*., 2017) are associated with self-compassion, other-directed compassion and empathic concern.

METHODS

Participants

The data comes from the population-based Northern Finland Birth Cohort 1986 (NFBC1986; University of Oulu, 1986). The original sample consisted of 9,479 persons born in the provinces of Oulu and Lapland in Finland between July 1985 and June 1986. At the beginning, the cohort covered 99% of the deliveries in the area within the target period. So far, there have been six measurement points covering the whole sample: the follow-up of pregnancy and delivery and follow-ups at ages 1, 7, 8, 15–16 and 33–35. The present study utilizes data from the follow-up at 15–16 years in 2001 and from the follow-up at 33–35 years in 2019–2020.

For the follow-up at 15–16 years, all cohort members and their parents with available postal address (N = 9,215, 97.2% of the original cohort) were invited to participate. Clinical data was obtained from 6,795 participants (73.7% of the invited cohort members). The questionnaire with the information on parental education was filled by 6,866 parents (74.5% of the invited parents). For the 33–35-year follow-up, all cohort members with postal address information available at the Finnish Population Register Centre were sent Webropol links to four questionnaires on health and well-being. The background questionnaire with the information on education was filled by 3,224 participants (36.2% of the original cohort) and the opinions and experiences questionnaire with information on self-compassion, other-directed compassion and empathic concern by 2,347 participants (26.4% of the original cohort). All cohort members with residence within a radius of 250 kilometers from Oulu, Finland (N = 5,717, 19.2% of the original cohort) were invited to participate in a clinical study. Clinical data was obtained from 1,807 participants (31.4% of the invited cohort members).

The present study included samples for cross-sectional and longitudinal analyses. From the original sample, participants with available data on all dependent variables (self-compassion, other-directed compassion and empathic concern) were chosen for cross-sectional and longitudinal samples (N = 2,503). Participants without data on cholesterols and triglycerides at age 33–35, altogether 1,038 participants, were omitted from the cross-sectional sample. Of the remaining 1,465 participants, six were omitted due to lack of information on highest education. Thus, the final sample for cross-sectional analyses consisted of 1,459 participants (911 women, 62.4%). The omitted participants were more likely to be men (54.1% in the original sample vs. 37.6% in the cross-sectional sample, $p < 0.001$). Based on register data from 2018, the omitted participants were less likely to have college or university education compared to the participants chosen for the sample (39.4% vs. 56.1%, $P < 0.001$). Register information on highest education was missing for 10.7% of the omitted participants.

Participants without data on cholesterols, triglycerides and fatty acids at age 15–16, altogether 806 participants, were omitted from the longitudinal sample. Of the remaining 1,697 participants, 188 were omitted due to lack of information on highest education and parental education. Thus, the final sample for longitudinal analyses was 1,509 participants (951 women, 63.0%). The omitted participants were more likely to be men (54.4% in the original sample vs. 37.0% in the longitudinal sample, $p < 0.001$). Based on register data from 2018, the omitted participants were less likely to have college or university education compared to the participants chosen for the sample (38.0% vs. 63.0%, $p < 0.001$). Register information on highest education was missing for 11.0% of the omitted participants.

Measures

Self-compassion. Self-compassion was measured with the shortened version of the Self-Compassion Scale (Neff, 2003; Raes, Pommier, Neff & Van Gucht, 2011). The short form consists of 12 statements that are assessed on a six-point scale from 0 (*almost never*) to 5 (*almost always*). As the original 24-item scale, the SCS-SF measures six dimensions of self-compassion: self-kindness, self-judgment, common humanity, isolation, mindfulness and over-identification. The items measuring self-judgment, isolation and over-identification were reversed before scoring. Mean scores were computed for participants who had values for at least

50% of the items. The short form has the same psychometric properties as the long form and the two correlate almost perfectly (Raes *et al.*, 2011). The participants completed the questionnaire when they were 33–35 years old. Cronbach's alpha for self-compassion was 0.83 in the cross-sectional sample and 0.84 in the longitudinal sample.

Other-directed compassion. Other-directed compassion was assessed with the subscale for compassion in the dispositional positive emotions scale (Shiota, Keltner & John, 2006). The subscale consists of five statements that the respondent assesses on a seven-point scale from 1 (*strongly disagree*) to 7 (*strongly agree*). Mean scores were computed for participants who had values for at least 50% of the items. In an earlier study, the internal consistency, and the structural, convergent and discriminant validity of the scale have been found to be good (Dixson, Anderson & Keltner, 2018). The participants completed the questionnaire when they were 33–35 years old. Cronbach's alpha for other-directed compassion was 0.85 in the cross-sectional sample and 0.86 in the longitudinal sample.

Empathic concern. Empathic concern was assessed with the scale for empathic concern in the interpersonal reactivity index (Davis, 1980; Davis, 1983). The scale includes seven items that the respondent assesses on a five-point scale from 0 (*does not describe me well*) to 4 (*describes me very well*). Three items that measure the lack of empathic concern were reversed before scoring. Mean scores were computed for participants who had values for at least 50% of the items. The psychometric properties of the scale have been shown to be good (Davis, 1980; Konrath, 2013). The participants completed the questionnaire when they were 33–35 years old. Cronbach's alpha for empathic concern was 0.80 in the cross-sectional sample and 0.79 in the longitudinal sample.

Lipids. Serum lipids were measured at age 15–16 with blood tests conducted in a clinic using Cobas Integra 700 automatic analyzer (Hoffmann-LaRoche, Basel, Switzerland) after overnight fasting (Koponen, Mäki, Halonen, *et al.*, 2008). The lipids include total cholesterol, LDL cholesterol, HDL cholesterol, triglycerides, DHA, total omega-3 fatty acids, LA and total omega-6 fatty acids, all measured as mmol/L. Plasma levels of total cholesterol, LDL cholesterol, HDL cholesterol and triglycerides were also assessed at age 33–35 in a similar procedure.

Highest education. Information on participants' highest education level was acquired from questionnaires filled by the participants when they were 33–35 years old. The education level was classified into three categories (1 = comprehensive school, 2 = upper secondary education, 3 = college or university education). As there were only a few participants in the lowest category, it was combined with the category for upper secondary education.

Parental education. Information on participant's parental education level was acquired from questionnaires filled by the parents when the participants were 15–16 years old. The education level was classified into three categories (1 = comprehensive school, 2 = upper secondary education, 3 = college or university education).

Sex. The binary sex assigned at birth was reported by parents in a follow-up questionnaire of pregnancy and delivery.

Statistical analyses

Statistical analyses were conducted using IBM SPSS Statistics version 27. First, possible lipid × sex interactions in self-compassion, other-directed compassion and empathic concern were tested by conducting a series of multiple linear regression analyses. Testing for interactions between each lipid and sex revealed significant interactions of sex with total cholesterol, LA and total omega-6 fatty acids in empathic concern. All analyses were conducted separately for men and women with the split-file procedure. Previous research has often shown sex differences in associations between lipids and personality (e.g., Tomson-Johanson & Harro, 2018; Tomson-Johanson *et al.*, 2020), which further supported the separate analyses for men and women. After testing for lipid × sex interactions, Pearson's correlation coefficients were computed between all study variables. Subsequently, a series of multiple hierarchical linear regression analyses with two blocks of variables were conducted to test main effects for lipids in self-compassion, other-directed compassion and empathic concern. Self-compassion, other-directed compassion or empathic concern at age 33–35 was determined as a dependent variable and each was analyzed separately. First, at age 33–35, cross-sectional associations of lipids (total cholesterol, LDL cholesterol, HDL cholesterol, triglycerides) as continuous variables with dependent variables (self-compassion, other-directed compassion and empathic concern) were examined with regression analyses. In step 1, the covariate participant's highest education was set as an independent variable. In step 2, each of the lipids was set as an independent variable in separate analyses. Next, at ages 15–16 and 33–35, in longitudinal analyses, associations of lipids (total cholesterol, LDL cholesterol, HDL cholesterol, triglycerides, DHA, LA, total omega-3 fatty acids, total omega-6 fatty acids) as continuous variables with dependent variables (self-compassion, other-directed compassion and empathic concern) were examined with regression analyses. Participant's highest education and parental education were set as independent variables in step 1 and each of the measured lipids at age 15–16 was set as a continuous independent variable in separate analyses in step 2.

After conducting regression analyses on continuous variables, the cross-sectional and longitudinal relationships of cholesterols and triglycerides with self-compassion, other-directed compassion and empathic concern were examined treating cholesterols as categorical variables. Total cholesterol, LDL cholesterol, HDL cholesterol and triglycerides were categorized in accordance with the recommendations by the Finnish Current Care Guidelines (Duodecim, 2022) and European Guidelines (Piepoli *et al.*, 2017). According to the Guidelines, the recommended cholesterol levels are the following: total cholesterol less than 5.0 mmol/L, LDL cholesterol less than 3.0 mmol/L, HDL cholesterol more than 1.0 mmol/L for men and 1.2 mmol/L for women and triglycerides less than 1.7 mmol/L. Analyses were conducted with univariate general linear model comparing groups with cholesterol and triglyceride values within and outside the reference ranges. For the cross-sectional analyses, participant's highest education was set as a covariate and for the longitudinal analyses, participant's highest education and parental education were set as covariates.

To control the effect of a high number of statistical tests on false positive rate, the false discovery rate was set at $\alpha = 0.05$ for all analyses (Benjamini & Hochberg, 1995).

RESULTS

The descriptive statistics are shown in Table 1. The correlation coefficients for the cross-sectional and the longitudinal samples are shown in Tables 2 and 3. The only significant correlations of lipids with outcomes were between empathic concern and HDL cholesterol and LA in women in the longitudinal sample.

Associations of lipids as continuous variables with self-compassion, other-directed compassion and empathic concern

The results of the regression analyses are shown in Tables 4 and 5. In cross-sectional analyses, in women, higher triglycerides at age 33–35 were associated with lower empathic concern at age 33–35. None of the lipids were associated with other-directed compassion nor self-compassion. No cross-sectional associations were found in men. After controlling for the false discovery rate, the association of triglycerides with empathic concern found in women lost its statistical significance (Benjamini-Hochberg critical value 0.0125).

Table 1. *Descriptive statistics*

	Cross-sectional analyses						Longitudinal analyses					
	Men (N = 548)			Women (N = 911)			Men (N = 558)			Women (N = 951)		
	Mean	*SD*	Range	Mean	*SD*	Range	Mean	*SD*	Range	Mean	*SD*	Range
Self-compassion	3.06	0.68	1.00–4.83	2.85	0.79	0.25–5.00	3.02	0.73	0.58–4.92	2.84	0.79	0.25–5.00
Other-directed compassion	5.25	0.91	1.00–7.00	5.69	0.91	1.00–7.00	5.19	0.93	1.20–7.00	5.70	0.89	1.00–7.00
Empathic concern	2.47	0.57	0.57–4.00	2.84	0.60	0.57–4.00	2.44	0.59	0.14–4.00	2.83	0.59	0.86–4.00

	Mean (mmol/L)	*SD* (mmol/L)	Mean (mmol/L)	*SD* (mmol/L)	Mean (mmol/L)	*SD* (mmol/L)	Mean (mmol/L)	*SD* (mmol/L)
Total cholesterol	4.88	0.87	4.46	0.79	4.07	0.68	4.42	0.78
LDL cholesterol	3.04	0.78	2.53	0.72	2.17	0.53	2.30	0.58
HDL cholesterol	1.35	0.31	1.57	0.35	1.34	0.27	1.49	0.28
Triglycerides	1.11	0.84	0.84	0.46	0.81	0.46	0.83	0.39
DHA					0.13	0.04	0.15	0.05
Omega-3					0.42	0.11	0.46	0.12
LA					2.74	0.50	2.95	0.57
Omega-6					3.38	0.60	3.66	0.70
Highest education								
Comprehensive school or upper secondary education		284		(51.8%)	345 (37.9%)		241 (43.2%)	
290 (30.5%)								
College or university education		264		(48.2%)	566 (62.1%)		317 (56.8%)	
661 (69.5%)								
Parental education								
Comprehensive school					22 (3.9%)		44 (4.6%)	
Upper secondary education					404 (72.4%)		729 (76.7%)	
College or university education					132 (23.7%)		178 (18.7%)	

Table 2. *Pearson's correlation coefficients for the cross-sectional sample*

Men							
Women	1.	2.	3.	4.	5.	6.	7.
1.Self-compassion	–	0.098*	0.082	0.041	0.049	0.040	−0.009
2. Other-directed compassion	0.172***	–	0.658***	−0.052	−0.039	−0.055	−0.001
3. Empathic concern	0.117***	0.648***	–	−0.031	−0.039	−0.001	0.021
4. Total cholesterol	0.006	0.014	0.004	–	0.893***	0.181***	0.386***
5. LDL cholesterol	−0.032	−0.015	−0.032	0.877***	–	−0.120**	0.241***
6. HDL cholesterol	0.031	0.049	0.056	0.306***	−0.138***	–	−0.303***
7. Triglycerides	−0.031	−0.057	−0.065	0.417***	0.398***	−0.111**	–

Notes: Correlations in women are reported below the diagonal and correlations in men are reported above the diagonal.
*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.

In longitudinal analyses, in women, higher HDL cholesterol, total cholesterol and LA at age 15–16 were associated with higher empathic concern at age 33–35. None of the lipids were associated with other-directed compassion nor self-compassion. No longitudinal associations were found in men. After the procedure related to the false discovery rate, of the significant associations found in women, only the longitudinal association of HDL cholesterol remained significant (Benjamini-Hochberg critical value 0.00625).

Associations of lipids as categorical variables and self-compassion, other-directed compassion and empathic concern

The results on categorical variables are shown in Tables 6 and 7. In cross-sectional analyses, in women, having HDL cholesterol level within the recommendations (i.e., over 1.2 mmol/L) was associated with higher other-directed compassion and higher empathic concern compared to having HDL cholesterol level 1.2 mmol/L or lower. These associations remained significant after controlling for the false discovery rate (Benjamini-Hochberg

Table 3. *Pearson's correlation coefficients for the longitudinal sample*

Men											
Women	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. Self-compassion	–	0.056	0.041	−0.012	−0.027	0.026	−0.033	−0.038	−0.039	−0.015	−0.022
2. Other-directed compassion	0.161***	–	0.669***	−0.028	−0.040	0.028	−0.011	−0.020	−0.037	−0.018	−0.017
3. Empathic concern	0.126***	0.681***	–	−0.053	−0.068	0.042	−0.065	−0.041	−0.060	−0.060	−0.060
4. Total cholesterol	−0.036	0.034	0.062	–	0.904***	0.218***	0.308***	0.536***	0.586***	0.713***	0.731***
5. LDL cholesterol	−0.034	0.017	0.026	0.904***	–	−0.151***	0.350***	0.494***	0.571***	0.659***	0.662***
6. HDL cholesterol	0.002	0.052	0.089**	0.280***	−0.070*	–	−0.361***	0.099*	0.028	0.151***	0.185***
7. Triglycerides	−0.037	−0.027	−0.018	0.384***	0.437***	−0.263***	–	0.231***	0.310***	0.232***	0.243***
8. DHA	0.000	0.010	0.011	0.418***	0.383***	0.163***	0.245***	–	0.958***	0.608***	0.679***
9. Omega-3	−0.003	0.022	0.007	0.469***	0.466***	0.092**	0.295***	0.962***	–	0.617***	0.680***
10. LA	0.015	0.049	0.065*	0.673***	0.646***	0.190***	0.299***	0.614***	0.624***	–	0.992***
11. Omega-6	0.014	0.047	0.061	0.676***	0.634***	0.224***	0.306***	0.684***	0.992***	0.686***	–

Notes: Correlations in women are reported below the diagonal and correlations in men are reported above the diagonal.
*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.

critical value 0.0125). There were no cross-sectional associations in men.

When treating cholesterols as categorical variables, none of the lipids was associated with self-compassion, other-directed compassion or empathic concern in longitudinal analyses in men or in women.

DISCUSSION

This is the first study that has investigated whether lipids are associated with self-compassion, other-directed compassion and empathic concern in adulthood. Our results suggest that in women, higher HDL cholesterol in adolescence is associated with higher empathic concern in adulthood and having an HDL cholesterol level over 1.2 mmol/L (i.e., within the recommended level) in adulthood is associated with higher other-directed compassion and higher empathic concern in adulthood, as compared to having an HDL cholesterol level 1.2 mmol/L or lower.

Our hypothesis of a positive association between HDL cholesterol and empathic concern gained support in women in both cross-sectional and longitudinal analyses. In a British population-based cohort study by Manczak and Gotlib (2019), higher HDL cholesterol at birth predicted better skills in emotion regulation and interpersonal functioning at age 5 in both boys and girls. As being compassionate requires social and emotional skills (Roeser *et al.*, 2018), our results are in line with those of Manczak and Gotlib (2019). Low HDL cholesterol has been associated with aggressive behavior in schizophrenic women (Herceg *et al.*, 2022) as well as angry hostility in young women in the normal population (Roh, Kim, Shim, *et al.*, 2014). Aggression and hostility are antisocial traits, which, in turn, have been linked with lower affective empathy (Campos *et al.*, 2022; Miller & Eisenberg, 1988). Thus, these results also seem to be in line with ours. The emergence of both cross-sectional and longitudinal associations may indicate that, in women, HDL cholesterol is important for empathic concern regardless of age. The associations in adulthood and in adolescence seem to have distinct patterns though, as the cross-sectional association first emerged when HDL cholesterol was categorized according to cholesterol recommendations.

Although no associations were found for continuous measures of lipids and other-directed compassion, our hypothesis concerning HDL cholesterol and other-directed compassion gained support in cross-sectional analyses conducted on the categorical measure of HDL cholesterol. The longitudinal associations between HDL cholesterol and other-directed compassion were in the same direction but did not reach significance. The results suggest that having HDL cholesterol within the recommendations (i.e., over 1.2 mmol/L) might be associated with high other-directed compassion in adulthood in women. These results are in line with those of a study by Herceg *et al.* (2022), in which aggressive and non-aggressive schizophrenic women were compared in terms of lipid levels. It was found that aggressive women had HDL cholesterol below the reference value (1.2 mmol/L) almost three times as often as non-aggressive women. Total cholesterol, LDL cholesterol and triglycerides were not associated with aggressive behavior in that

Table 4. *Lipids in adulthood as predictors of self-compassion, other-directed compassion and empathic concern in adulthood in men and women*

		Self-compassion			Other-directed compassion			Empathic concern		
		β	*P*	ΔR^2	β	*P*	ΔR^2	β	*P*	ΔR^2
Men	Total cholesterol	0.060	0.167	0.003	−0.063	0.145	0.004	−0.035	0.416	0.001
	LDL cholesterol	0.066	0.124	0.004	−0.049	0.259	0.002	−0.043	0.318	0.002
	HDL cholesterol	0.039	0.361	0.002	−0.055	0.201	0.003	−0.001	0.975	0.000
	Triglycerides	0.003	0.942	0.000	−0.008	0.856	0.000	0.019	0.666	0.000
Women	Total cholesterol	0.012	0.713	0.000	0.009	0.776	0.000	0.001	0.971	0.000
	LDL cholesterol	−0.024	0.476	0.001	−0.021	0.522	0.000	−0.037	0.268	0.001
	HDL cholesterol	0.027	0.409	0.001	0.052	0.119	0.003	0.057	0.083	0.003
	Triglycerides	−0.027	0.421	0.001	−0.061	0.067	0.004	−0.067	0.042[a]	0.005

[a]*Note*: Did not remain significant after controlling for the false discovery rate.

Table 5. *Lipids in adolescence as predictors of self-compassion, other-directed compassion and empathic concern in adulthood in men and women*

		Self-compassion			Other-directed compassion			Empathic concern		
		β	*P*	ΔR^2	β	*P*	ΔR^2	β	*P*	ΔR^2
Men	Total cholesterol	−0.007	0.861	0.000	−0.027	0.530	0.001	−0.051	0.228	0.003
	LDL cholesterol	−0.023	0.583	0.001	−0.039	0.363	0.001	−0.066	0.122	0.004
	HDL cholesterol	0.026	0.541	0.001	0.028	0.511	0.001	0.041	0.335	0.002
	Triglycerides	−0.034	0.426	0.001	−0.013	0.768	0.000	−0.066	0.125	0.004
	DHA	−0.051	0.230	0.003	−0.026	0.541	0.001	−0.048	0.261	0.002
	Omega-3	−0.052	0.227	0.003	−0.043	0.318	0.002	−0.067	0.120	0.004
	LA	−0.019	0.659	0.000	−0.019	0.652	0.000	−0.060	0.155	0.004
	Omega-6	−0.026	0.536	0.001	−0.018	0.664	0.000	−0.061	0.151	0.004
Women	Total cholesterol	−0.028	0.384	0.001	0.029	0.368	0.001	0.064	0.049[a]	0.004
	LDL cholesterol	−0.026	0.421	0.001	0.012	0.716	0.000	0.028	0.399	0.001
	HDL cholesterol	0.002	0.959	0.000	0.052	0.112	0.003	0.089	0.006[b]	0.008
	Triglycerides	−0.028	0.390	0.001	−0.031	0.347	0.001	−0.016	0.620	0.000
	DHA	0.000	0.991	0.000	0.009	0.776	0.000	0.010	0.747	0.000
	Omega-3	−0.003	0.936	0.000	0.021	0.508	0.000	0.007	0.836	0.000
	LA	0.019	0.551	0.000	0.047	0.147	0.002	0.066	0.042[a]	0.004
	Omega-6	0.019	0.567	0.000	0.045	0.169	0.002	0.062	0.056	0.004

[a]*Notes*: Did not remain significant after controlling for the false discovery rate.
[b]Remained significant after controlling for the false discovery rate.

study. It should, however, be noted that the associations observed in a clinical sample, such as that of Herceg *et al*. (2022), do not necessarily reflect those in the normal population.

The associations of HDL cholesterol with other-directed compassion and empathic concern were only observed in women, not in men. Research suggests that lipid levels, including HDL cholesterol, differ between men and women (Cartocci *et al*., 2017; Davis, Williams, Oganov, *et al*., 1996). It is still unclear what causes the sex differences in lipid levels, but one explanation is sex hormones – and the fact that in women, the cholesterol levels change as the production of sex hormones, especially estrogen, changes (due to for example menstrual cycle, pregnancy and menopause), supports this notion (Holven & van Lennep, 2023). There also seems to be cultural variation in the sex differences (Davis *et al*., 1996), which indicates that, potentially, not only biological but also social factors contribute to the sex differences in lipid levels. Thus, it is possible that the reasons for the observed sex differences in our study have to do with both biology and socialization.

Despite the contrary hypothesis, high total cholesterol and high LDL cholesterol were not associated with high other-directed compassion and high empathic concern in this study. Low total cholesterol and low LDL cholesterol have been linked to higher aggression (Hillbrand & Spitz, 1999; Sahebzamani *et al*., 2013; Suneson *et al*., 2019), which, as mentioned above, is an antisocial trait associated with less affective empathy (Campos *et al*., 2022; Miller & Eisenberg, 1988). This led us to hypothesize that high total cholesterol and LDL cholesterol would be associated with higher other-directed compassion and empathic concern. Our results indicate otherwise and are in line with those of Herceg *et al*. (2022) who noted that only HDL cholesterol, but not total cholesterol, LDL cholesterol or triglycerides, was associated with aggressive behavior in schizophrenic women. Even though cholesterols are important for neurodevelopment, longitudinal studies on their significance for personality are scarce (e. g. Manczak & Gotlib, 2019; Tomson-Johanson *et al*., 2020). Our study is the first to examine the relation of cholesterols with other-directed compassion and empathic concern.

The hypotheses concerning the associations of DHA and total omega-3 fatty acids with other-directed compassion and empathic concern did not gain support. In a previous study, the intake of DHA and fish rich in omega-3 fatty acids in childhood was

Table 6. *Univariate general linear model results in the cross-sectional sample*

			Self-compassion					Other-directed compassion					Empathic concern				
		N	Mean	*SD*	F(df)	*P*	Partial η^2	Mean	*SD*	F(df)	*P*	Partial η^2	Mean	*SD*	F(df)	*P*	Partial η^2
Men	TC < 5.0 mmol/L	329	3.04	0.69	0.922 (1)	0.337	0.002	5.29	0.92	2.175 (1)	0.141	0.004	2.48	0.59	0.384 (1)	0.536	0.001
	TC ≥ 5.0 mmol/L	219	3.08	0.67				5.18	0.91				2.45	0.53			
	LDL < 3.0 mmol/L	293	3.03	0.70	1.963 (1)	0.162	0.004	5.25	0.92	0.118 (1)	0.732	0.000	2.47	0.59	0.001 (1)	0.977	0.000
	LDL ≥ 3.0 mmol/L	255	3.09	0.67				5.24	0.90				2.47	0.54			
	HDL ≤ 1.0 mmol/L	62	3.03	0.81	0.085 (1)	0.771	0.000	5.37	0.77	1.192 (1)	0.275	0.002	2.53	0.57	0.787 (1)	0.375	0.001
	HDL > 1.0 mmol/L	486	3.06	0.66				5.23	0.93				2.46	0.56			
	Trigly < 1.7 mmol/L	478	3.06	0.68	0.153 (1)	0.695	0.000	5.25	0.93	0.011 (1)	0.915	0.000	2.47	0.57	0.036 (1)	0.849	0.000
	Trigly ≥ 1.7 mmol/L	70	3.06	0.69				5.25	0.76				2.49	0.54			
Women	TC < 5.0 mmol/L	713	2.86	0.79	0.245 (1)	0.621	0.000	5.70	0.91	0.375 (1)	0.541	0.000	2.85	0.60	0.575 (1)	0.449	0.001
	TC ≥ 5.0 mmol/L	198	2.82	0.79				5.67	0.90				2.82	0.58			
	LDL < 3.0 mmol/L	721	2.87	0.78	0.387 (1)	0.534	0.000	5.70	0.91	0.583 (1)	0.445	0.001	2.86	0.60	1.753 (1)	0.186	0.002
	LDL ≥ 3.0 mmol/L	190	2.81	0.82				5.66	0.90				2.80	0.58			
	HDL ≤ 1.2 mmol/L	120	2.74	0.73	2.540 (1)	0.111	0.003	5.44	0.91	11.742 (1)	<0.001[a]	0.013	2.67	0.62	12.445 (1)	<0.001[a]	0.014
	HDL > 1.2 mmol/L	791	2.87	0.80				5.73	0.91				2.87	0.59			
	Trigly < 1.7 mmol/L	862	2.85	0.79	0.092 (1)	0.761	0.000	5.70	0.91	0.180 (1)	0.671	0.000	2.85	0.60	0.035 (1)	0.852	0.000
	Trigly ≥ 1.7 mmol/L	49	2.88	0.85				5.65	0.88				2.83	0.61			

Notes: TC = total cholesterol; LDL = LDL cholesterol; HDL = HDL cholesterol; Trigly = triglycerides.
[a]Remained significant after controlling for the false discovery rate.

Table 7. *Univariate general linear model results in the longitudinal sample*

			Self-compassion					Other-directed compassion					Empathic concern				
		N	Mean	*SD*	F(df)	*P*	Partial η^2	Mean	*SD*	F(df)	*P*	Partial η^2	Mean	*SD*	F(df)	*P*	Partial η^2
Men	TC < 5.0 mmol/L	516	3.02	0.73	0.180 (1)	0.672	0.000	5.19	0.95	0.015 (1)	0.902	0.000	2.45	0.59	1.445 (1)	0.230	0.003
	TC ≥ 5.0 mmol/L	42	2.96	0.71				5.21	0.80				2.34	0.53			
	LDL < 3.0 mmol/L	529	3.01	0.73	0.075 (1)	0.784	0.000	5.19	0.94	0.036 (1)	0.850	0.000	2.45	0.59	1.050 (1)	0.306	0.002
	LDL ≥ 3.0 mmol/L	29	3.05	0.74				5.16	0.86				2.34	0.59			
	HDL ≤ 1.0 mmol/L	45	3.01	0.68	0.022 (1)	0.882	0.000	5.04	0.76	1.320 (1)	0.251	0.002	2.32	0.49	2.104 (1)	0.147	0.004
	HDL > 1.0 mmol/L	513	3.02	0.74				5.20	0.95				2.45	0.59			
	Trigly < 1.7 mmol/L	535	3.02	0.73	0.265 (1)	0.607	0.000	5.19	0.94	0.091 (1)	0.763	0.000	2.45	0.59	1.380 (1)	0.241	0.002
	Trigly ≥ 1.7 mmol/L	23	2.92	0.76				5.13	0.95				2.30	0.58			
Women	TC < 5.0 mmol/L	774	2.84	0.78	0.082 (1)	0.774	0.000	5.68	0.91	1.648 (1)	0.199	0.002	2.81	0.60	3.658 (1)	0.056	0.004
	TC ≥ 5.0 mmol/L	177	2.84	0.81				5.78	0.80				2.91	0.57			
	LDL < 3.0 mmol/L	855	2.86	0.79	3.010 (1)	0.083	0.003	5.69	0.89	0.014 (1)	0.904	0.000	2.83	0.59	0.801 (1)	0.371	0.001
	LDL ≥ 3.0 mmol/L	96	2.70	0.78				5.72	0.92				2.88	0.61			
	HDL ≤ 1.2 mmol/L	150	2.87	0.84	0.235 (1)	0.628	0.000	5.57	0.86	3.338 (1)	0.068	0.004	2.75	0.60	3.578 (1)	0.059	0.004
	HDL > 1.2 mmol/L	801	2.84	0.78				5.72	0.90				2.85	0.59			
	Trigly < 1.7 mmol/L	914	2.84	0.79	0.020 (1)	0.889	0.000	5.70	0.90	0.160 (1)	0.690	0.000	2.84	0.59	0.695 (1)	0.405	0.001
	Trigly ≥ 1.7 mmol/L	37	2.81	0.76				5.64	0.77				2.75	0.63			

Note: TC = total cholesterol; LDL = LDL cholesterol; HDL = HDL cholesterol; Trigly = triglycerides.

associated with lower risk of hostility in early adulthood (Iribarren *et al*., 2004). Experimental research also suggests that omega-3 supplementation has an inverse effect on aggression (Gajos & Beaver, 2016). As mentioned above, hostility and aggression are antisocial traits associated with less affective empathy (Campos *et al*., 2022; Miller & Eisenberg, 1988) but, obviously, results on aggression are not necessarily equivalent to results on other-directed compassion or empathic concern.

Besides the assumed associations, we examined the relationships of triglycerides, LA and omega-6 fatty acids with self-compassion, other-directed compassion and empathic concern. Before controlling for the false discovery rate, high triglycerides in adulthood were significantly associated with low empathic concern in adulthood in women, whereas high LA in adolescence was significantly associated with high empathic concern. However, these associations did not survive the multiple comparisons procedure and were, thus, considered insignificant. Further research is warranted to establish the relationships between triglycerides, LA and empathic concern.

Our analyses on self-compassion were exploratory in nature, due to lack of previous research on self-compassion or similar outcomes. Although associations with other-directed compassion and empathic concern were found, none of the lipids examined were associated with self-compassion, which indicates that lipids likely do not play a role in self-compassion. Diverging findings of other-directed compassion and empathic concern as compared to those of self-compassion are not surprising, since the correlations of self-compassion with these other two traits are low.

Apart from the associations of HDL cholesterol with other-directed compassion and empathic concern in women, most of the tested associations between lipids and compassion were insignificant. One probable explanation for the scarcity of significant associations in this study is the time of measurement. Lipids are essential for myelination, which progresses most rapidly during early postnatal periods (Chang, Ke & Chen, 2009; Saher, Brügger, Lappe-Siefke, *et al*., 2005). The production of lipids peaks early in the neurodevelopment (Bazinet & Layé, 2014; Cartocci *et al*., 2017). So, it is possible that the significance of lipids on personality development is more prominent in pre- and early post-natal periods. Measuring lipids first in adolescence and in adulthood may have been too late to detect the possible associations of lipids with compassion-related phenomena. Particularly, adolescence may not have been the optimal timepoint as there are major hormonal changes going on in the body at the same time. As mentioned above, there are sex differences in lipid levels that are associated with hormones and these changes become evident after early childhood (Holven & van Lennep, 2023).

LIMITATIONS AND STRENGTHS

There are several limitations to this study that should be mentioned. The most notable limitation is that the baseline levels of other-directed compassion, self-compassion and empathic concern could not be controlled for as the dependent variables were assessed only once, in adulthood. Thus, assumptions of causality cannot be made. The self-report questionnaires used in this study may be susceptible to social desirability bias. It should

also be considered that the total cholesterol and LDL cholesterol levels in the cross-sectional sample did not correspond to the ones in the same age group (30–39 years) in the Finnish population, especially in women. According to the National FinHealth Study 2017 (Koponen, Borodulin, Lundqvist, Sääksjärvi & Koskinen, 2018), in the age group of 30–39 years, the total cholesterol was higher than recommended in 51.2% of men and 37.6% of women, LDL cholesterol higher than recommended in 53.3% of men and 33.5% of women and HDL cholesterol lower than recommended in 12% of men and 11% of women. In the cross-sectional sample of this study, the corresponding percentages were 45.8% and 21.7% for total cholesterol, 46.5% and 20.9% for LDL cholesterol and 11.3% and 13.2% for HDL cholesterol. Thus, total cholesterol and LDL cholesterol seem somewhat lower in the women of this sample compared to the normal population. HDL cholesterol levels were, however, close to the ones observed in the normal population.

The most considerable strengths of this study are the general population sample, the longitudinal cohort data and the fairly large sample size that contribute to the generalizability of our findings. It should, however, be mentioned that the samples of this study were more female-dominated and more educated than the original sample of the cohort. Another strength is the inclusion of various lipids and several compassion-related response variables as well as both cross-sectional and longitudinal analyses. In the future, it may be important to assess lipid levels at a younger age (and preferably during prenatal and early postnatal period) as the influence of lipids might be more pronounced earlier in neurodevelopment (e.g., Bazinet & Layé, 2014; Fernstrom, 2000; Zhang & Liu, 2015). Other biological factors worth examining would be, for example, essential amino acids that must be obtained from the diet, especially the ones that are precursors for neurotransmitters, such as tryptophan (precursor for serotonin). It is also possible that, instead of lipids per se, their mutual ratios would be of importance. Some studies have shown that the ratios of specific omega-3 and omega-6 fatty acids are associated with psychological functioning, such as neuroticism, depression and impulsivity (Conklin *et al*., 2007) and aggression (Itomura, Hamazaki, Sawazaki, *et al*., 2005).

CONCLUSION

Research on biomarkers for adaptive psychological functioning such as self- and other-directed compassion is still in its infancy but there are grounds for pursuing it. The current theoretical reasoning suggests that other-directed compassion has emerged as a result of evolutionary processes, to ensure the survival of the human race (Goetz *et al*., 2010). Research implies that the prosocial traits are, in fact, genetically influenced (Ando, Suzuki, Yamagata, *et al*., 2004; Knafo-Noam, Uzefovsky, Israel, Davidov & Zahn-Waxler, 2015). If that is the case – if compassion is an innate trait characteristic of human beings encoded in our DNA – there will likely be biological factors behind it that are worth investigating.

More research on the relationships of lipids with self-compassion, other-directed compassion and empathic concern is warranted before drawing certain conclusions on their practical impact. If, however, the association of HDL cholesterol with other-directed compassion and empathic concern observed in women would gain support in replication studies, we could possibly enhance prosocial traits not just by psychological interventions but also by physiological ones, such as physical exercise and diet. Examining the associations of biological factors with compassion may also contribute to finding explanations to why women seem to be more compassionate than men and men more self-compassionate than women.

This study was the first to examine the relationships of lipids with self-compassion, other-directed compassion and empathic concern. The longitudinal results suggest that higher HDL cholesterol is associated with higher empathic concern in women. The cross-sectional results also suggest that HDL cholesterol above the level of 1.2 mmol/L is associated with higher other-directed compassion and empathic concern in adult women. The present study provides the first evidence that biological factors such as lipids might play a role in the development of empathic concern and other-directed compassion.

Northern Ostrobothnia Hospital District Ethical Committee granted permission for the study. Written informed consent was required from the participants and the parents of minor participants at each measurement point. This study was supported by Academy of Finland (grant number 308676; MH) and the Finnish Cultural Foundation (grant number 00220809; SP). The funding sources had no contribution to the research design, the collection, analysis and interpretation of data, the writing process nor the submission of the article. The study has not been pre-registered. The data used in this study contains identifiable, personal information and must be protected according to applicable data protection legislation, such as such as the General Data Protection Regulation (Regulation [EU] 2016/679) and the Finnish Data Protection Act (code 1050/2018). Thus, the sharing of the data is not possible. We state that the article adheres to the guidelines for ethical conduct and report of research. We also confirm that the work has not been published elsewhere nor is it under consideration with any other journal. There are no conflicts of interests to declare.

DATA AVAILABILITY STATEMENT

The data used in this study contains identifiable, personal information and must be protected according to applicable data protection legislation, such as such as the General Data Protection Regulation (Regulation (EU) 2016/679) and the Finnish Data Protection Act (code 1050/2018). Thus, the sharing of the data is not possible.

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Received 8 November 2023, Revised 31 May 2024, accepted 12 June 2024