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Personality traits' associations with basal metabolic rate, height and weight
Uurimistöo projekt

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Isiksuseomadused, baasmetabolism, pikkus ja kehakaal

Kokkuvõte

Seoseid loomade isiksuse, suuruse, käitumise ja metabolismi vahel on palju uuritud, aga vähe on uuritud, kas sarnased seosed kehtivad inimeste kohta. Selle töö eesmärk on uurida seoseid isiksuse, kehakaalu, pikkuse ja baasmetabolismi (BMR) vahel. Seoste uurimiseks kasutati suurt andmestikku ($n = 19519$), mis pärineb Synthetic Aperture Personality Assessment projekti kodulehelt. BMR korreleeris enamus dimensioonidega, aga tugevaimaid korrelatsioone leiti BMR ja küsimuste vahel, millega olid seotud impulsiivsus ja liberaalsus. Kehakaal korreleeris samuti tugevalt nende samade küsimustega. Korrelatsioonid pikkuse ja dominantsuse vahel olid nõrgad aga statistiliselt olulised. Tulemused näitasid, et seosed uuritud tegurite vahel oli spetsiifilised aga piiratud.

Märksõnad: isiksus, baasmetabolism, SAPA, IPIP-NEO, pikkus, kehakaal, aktiivsus, dominantsus

Personality traits' associations with basal metabolic rate, height and weight

Abstract

Many animal studies have demonstrated correlations between behaviour, personality, size and metabolism but research looking at these associations in humans is quite limited. This study's aim was to explore the associations between personality and physical traits such as basal metabolic rate (BMR), height and weight using a large ($n = 19519$), publicly available database sourced from the Synthetic Aperture Personality Assessment project. BMR significantly correlated with almost all personality domains while the strongest correlations were with items related to impulsiveness and liberalism. These same items also had similarly strong correlations with weight. A weak but significant correlation was also found between height and assertiveness items. These results suggest both limited and specific interrelations exist between personality and physical traits.

Keywords: personality, basal metabolism, SAPA, IPIP-NEO, height, weight, activity level, assertiveness

1. INTRODUCTION

In the field of psychology, physical measures are useful as they provide the type of objective information about psychological phenomena that self-report measures cannot usually provide. For example, much research has been done on the physiological aspects of emotion (e.g. Mauss & Robinson, 2009), providing important insights into both the nature of emotion and its somatic expression. The amount of questionnaire-based work done on personality traits has been extensive, however the links between personality, physiology and physical traits have been much less explored. A better comprehension of these links would help to broaden our understanding of personality and perhaps both its consequences and proximal causes. This study will attempt to further expand our current knowledge of the physiological and physical correlates of personality by investigating the relationships between human personality, height, weight and basal metabolic rate.

The most popular means of measuring personality is through questionnaires. The most commonly used questionnaire in personality research is the NEO Revised Personality Inventory (NEO-PI-R), developed by Costa and McCrae (1992). This, and other similar scales are based on the structured use of natural language to describe and assess personality traits and/or aspects of observable behaviour (McCrae & John, 1992). Based on the covariance and factor structure of these described traits, results are typically presented as five broad personality dimensions (Haig, 2005). A key premise of the factorial approach is that the traits and items associated with each dimension share common and reliable underlying causes or mechanisms (Haig, 2005). Various biologically based models (e.g., Eysenck's three factor model; Eysenck, 1952; Eysenck et al., 1985) have been developed to explain such underlying causes of personality, focussing mostly on brain-based explanations (DeYoung, 2010).

Looking beyond neuropsychology, personality also appears to have some links with somatic phenomena such as heart function (Kemp et al., 2010; Koelsch et al., 2012; Zohar et al., 2013), muscle function (Goldstein, 1964; Nimbarte et al., 2012) and adiposity (Arumäe et al., 2022; Terracciano et al., 2009). Lahti and colleagues (2013) also found that growth rates in childhood predicted personality traits in late adulthood. Arguably, all somatic and psychological functioning depends upon the energy-producing and growth-enabling role of metabolism. It is surprising, then, that only a few studies have been published on the

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relationship between basal metabolic rate and personality. One study (Terracciano et al., 2013), found that resting energy expenditure and NEO-PI-R inventory scores were generally uncorrelated while Bergeron et al. (2021) found that resting metabolic rate negatively correlated with the extraversion domain of the Big 5 Inventory test. Arumäe and colleagues (2022) however commented that the sample sizes of these earlier studies may have been too small to reveal robust correlations with personality. Their own study (Arumäe et al., 2022) employed a larger sample (n = 2547) and found that BMR was consistently correlated with assertiveness. This suggests that their work is in agreement with various studies of non-human species showing that BMR correlates with traits of dominance. In contrast to human studies, the literature regarding personality and metabolism in non-human subjects is incredibly rich and diverse, featuring a wide range of species, environments and research techniques.

The study of metabolism employs a variety of measurement tools such as basal metabolic rate (BMR), resting metabolic rate (RMR), maximum metabolic rate (MaxMR) and aerobic scope. Both BMR and RMR are measured while at rest and are considered as being equivalent (Biro & Stamps, 2010). MaxMR is a recording of energy consumption during intense activity, usually forced locomotion (Biro et al., 2018), while aerobic scope is the difference between BMR and MaxMR (Biro et al., 2018). Metabolic rate is generally seen as being consistent over time (Careau et al., 2008), but BMR can also rise to compensate for changes in environment (e.g., in winter; McClune et al., 2015), or temporarily fall to compensate for the energy consumption related to large increases in activity or stress (Boratyński, 2020). Results with MaxMR, which marks the upper limit of activity for an individual, are again not uniform, but a higher MaxMR generally means that an individual can more often engage in higher energy activities while also being able to recover more quickly (Biro et al., 2018). Further to this, a large aerobic scope - where BMR is low and MaxMR is high - seems to offer advantages for animals that spend large amounts of energy on locomotion, such as animals patrolling a large home range (Boratyński, 2020). This expanded aerobic scope however may mean that an individual may have a relatively low BMR (Boratyński, 2020), perhaps in order to compensate for higher total levels of energy consumed through locomotion (Biro et al., 2018).

Although findings in non-human animal metabolic research are somewhat varied, it is understood that individuals with higher levels of BMR are generally more active (e.g., mice; Gębczyński & Konarzewski, 2009) while also being larger, more aggressive and dominant

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(e.g., Atlantic salmon; Cutts et al., 1998). See Biro & Stamps (2010) and Mathot et al., (2019) for reviews of this literature. It is not clear though whether their higher BMR is a product of an active and dominant personality, or whether they are active and dominant so as to support a consistently greater need for energy that comes with a higher basal metabolism.

This brief review shows that energy metabolism in various non-human species is complex. Some measurements of metabolism may also be misleading if used on their own. A low BMR may mean that an individual is less active, less dominant or perhaps suffering from stress or illness. It however may mean that they have high endurance or are more resilient to stressors (because of a large aerobic scope). In contrast, a consistently higher BMR is perhaps more meaningful in terms of behaviour as it is implicitly tied to increased daily energy needs and the higher levels of activity and dominance that this entails.

In humans, BMR can be estimated from a person's height and weight (Hasson et al., 2011), and is therefore likely to correlate with physical size. If there are links between personality and BMR, then personality traits may also be associated with physical size. As a higher BMR in non-human animals is often related to increased activity and dominance, then people with a higher BMR (and larger body size) may exhibit similar traits of higher activity and dominance. Although there is some empirical support for the hypothesis that height may be positively correlated with dominance (Melamed, 1992; Stulp et al., 2015), and studies showing that height is related to perceived dominance (Mailhos et al., 2017; Montepare, 1995; Undurraga et al., 2012), the evidence is limited and would benefit from further study.

The links between metabolism, height and personality can be investigated using personality questionnaires. They provide generally consistent means of measuring personality traits which can then be analysed against measures of height and metabolism. For example, Arumäe and colleagues (2022) used the NEO Personality Inventory-3 (McCrae & Costa 2010 as cited in Arumäe et al., 2022) to investigate the connections between personality traits and basal metabolic rate. Personality inventories are advantageous as it may be possible to analyse these results at different levels of specificity. For example, in the five-factor model, personality scores can be expressed as five broad dimensions (*extraversion, agreeableness, conscientiousness, openness to experience and neuroticism*). Each dimension however, can be composed of narrower groups of traits called facets. Each facet is in-turn composed of a group of similarly themed items (questions or assertions) called nuances (McCrae, 2015). In many contexts, the broad dimension scores provide a comprehensive and useful description

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of a person's enduring personality traits (McCrae & John, 1992; Ones et al., 1996). This has also been found to apply across cultures (Schmitt et al., 2007). The narrower facets can however provide a finer-grain resolution and reveal more specific information about behaviour (Margolis et al., 2020; Paunonen & Ashton, 2001; Paunonen et al., 2003) which can be useful in contexts such as understanding specific health problems (e.g., obesity, Terracciano et al., 2009; Vainik et al., 2019) and planning health interventions (e.g., reducing HIV spread, Trobst et al., 2002). Individual item scores (nuances) of course provide an even finer resolution (Möttus et al., 2017; Möttus & Rozgonjuk, 2021; Vainik et al., 2015).

Assuming that the reported links between metabolism, dominance and activity in non-human animals may also exist in humans, then of the five broad FFM personality dimensions, the dimension of *extraversion* would most likely account for the largest portion of variance within metabolism data. This is because the dimension of *extraversion* usually contains facets which are specific measures of activity and assertiveness, with assertiveness being the most conceptually similar construct to dominance in the FFM. The *extraversion* dimension however also contains other facets, such as *gregariousness*, which may not be so relevant to height or metabolism and so will affect the total covariance of the higher dimension. Investigating associations at the item level may also provide specific and meaningful insights. As height and weight are important contributors to the calculation of BMR, then it may also be informative to see how these are separately associated with key personality traits – that is, traits correlating strongly with BMR.

The general aim of this study is to investigate the associations between personality and physiological/physical variables – BMR, height and weight – and to assess how these results support previous work (e.g., Arumäe, 2022). As the data used for this study (described in the method section) may possess a relatively high degree of sampling error (e.g., online, self-report measures of personality, height and weight), then it may not be meaningful to present hypotheses for testing. A few specific questions however will be explored:

- 1) What are the correlations between personality traits and BMR and how are they expressed at the domain, facet and item level?
- 2) Does BMR correlate with levels of activity?
- 3) Does height correlate with levels of assertiveness?
- 4) Do height, weight and BMR correlate in similar ways with key personality traits?

2. METHOD

SAPA data

The current study will use data that has been collected online from over 48000 people who have completed a questionnaire connected with the Synthetic Aperture Personality Assessment project (SAPA; Condon et al, 2017). The SAPA project's aim is to collect large amounts of data for further analysis of personality dimensions (Condon et al., 2017), such as its synthesis into large covariance matrices (Revelle et al., 2021). The combining of small blocks of data into a larger whole, known as a *planned missing data* design, is used in other contexts such as large international research projects (e.g., the Program for International Student Assessment (PISA), Kaplan & Su, 2018). Every person who answers the online SAPA questionnaire is presented with a random selection of items from a subset (n= 696 items) of the International Personality Item Pool (IPIP), a collection of over 3200 publicly available personality scale items that are free to use and modify (IPIP Home, n.d.; Goldberg et al., 2006). This subset of 696 items was chosen for the SAPA project because these items are common to more than 200 public domain scales (Condon, 2014, as cited in Revelle et al., 2021).

The data to be analysed in this study were collected online between December 2015 and February 2017 and include item response data, socio-demographic data and measures of height and weight. Respondents were free to end the questionnaire at any time, meaning that the number of items completed on any occasion may vary from 1-696. On average, the number of items completed was 84. This means that the database consists of over 48000 individual sets of responses to randomly presented scale items. For this study, the responses to 300 of these 696 items were analysed. These 300 items are sourced from the IPIP-NEO (Goldberg, 1999), a freely available personality inventory which measures similar constructs to those found in the NEO Personality Inventory (NEO-PI, Costa & McCrae, 1992). SAPA data has been previously scored as five dimensions, in a similar way to the NEO-PI (Revelle et al., 2021) and has also been used at an individual item level to explore more specific relationships between variables (Revelle et al., 2021).

Preparation of data

Before undertaking any analyses, the data were filtered and modified. Around 67% of the original sample included data from participants who identified as living in the USA. As the

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equation used to calculate BMR in this study was also developed from a US sample (Mifflin et al., 1990), then participants from other nations were excluded from analyses as the equation may under- or overestimate BMR for different national subgroups. Data were also removed regarding participants that had not provided weight or height information. Some participants had provided self-reported height and weight estimates which seemed improbably large or small. To filter out such extreme values, only height and weight data that were within ± 3 standard deviations from the sample mean were used for analyses. Reported height data were converted from inches to centimetres and weight data was converted from pounds to kilograms. The final average heights of the sample (Table 1) were two to three centimetres larger than reported averages found in the US population (Fryar et al., 2021). Analyses were also restricted to people over the age of 18 as human metabolism studies have shown that children and adolescents have higher basal metabolic rates than adults (Pontzner et al., 2020). Before calculating domain and facet scores, items were reversed following an item key that was packaged with the SAPA database file.

As has been done in previous metabolism studies (e.g. Arumäe et al., 2022, Terracciano et al., 2013), the confounding influences of age and sex were corrected for. To achieve this, regression analyses were used to residualise each variable for age, age-squared and gender. The age-squared covariate was added to help control for the slowing of metabolism in later life. A nested partial ANOVA comparing a full BMR regression model (i.e. that which included the age-squared variable) and the reduced model confirmed that the full model fitted the data significantly better than the reduced model ($F(1) = 372.83, p < 0.01$). All residualised variables (BMR, personality scores, height, weight) followed a normal distribution. Before calculating residuals, all variables underwent standardization resulting in the mean value of each variable being set to zero and the standard deviation being 1. It has been reported (Iacobucci et al., 2016) that using mean-centred values helps to reduce the collinearity between the variables when a regression model contains a polynomial term.

Measures: BMR

BMR was estimated from height, weight, age and sex data using the Mifflin-St Jeor equation (Mifflin et al., 1990) which is a common technique for estimating human basal metabolism (Hasson et al., 2011).

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The equation is as follows:

$9.99 \times \text{weight} + 6.25 \times \text{height} - 4.92 \times \text{age} + 166 \times \text{sex} - 161$, where sex=1 for men and sex = 0 for women.

Measures: Domain and facet scores

Personality scores were calculated by averaging the scores of defined subsets (domains, facets) of IPIP-NEO personality items. Individuals were only included in the calculation of a domain if they had answered at least five out of 60 possible IPIP-NEO items in a particular domain or at least three out of ten items in a given facet. Descriptive statistics for both domain and facet data can be found in Appendix 1.

Statistical analyses

In order to investigate the relationships between basal metabolism and personality, Spearman's rhos were calculated between residualised BMR and residualised personality measures – i.e. domains, facets and items. To investigate the relationship between BMR and the activity level of participants, items within the *E4: Activity Level* facet were investigated. Facets that showed significant correlations with BMR were also investigated at the item level.

One aim of this study was to investigate relationships between the height of participants and personality scores relating to assertive behaviour. This was done by calculating the correlations between residualised height data and residualised scores from the *E3: Assertiveness* facet. These relationships were also investigated at the item level.

When calculating BMR, the Mifflin-St Jeor equation combines height, weight, age and gender data (Mifflin et al., 1990). After age and gender have been adjusted for in personality scores, the remaining variance connected with BMR residuals can generally be divided between height and weight variables. To investigate the relative contributions of weight and height regarding important personality items, correlations were also calculated between residualised height and weight on the one hand and items that significantly correlated with BMR on the other.

As the analyses described above involved large numbers of variables, then the problem of multiple testing was important to address (Benjamini & Hochberg, 1995). To counteract this problem, a false discovery rate (FDR) adjustment procedure was performed on the *p*-values

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of all correlation analyses. Data were preprocessed and analyses conducted using the R programming language and RStudio statistics software package (RStudio Team, 2022).

Ethics statement

Analyses were performed on existing data that is freely available online, so there was no conflict with ethical principles and no need for permission from the any ethics committees.

3. RESULTS

Participants

After exclusions, the final sample entailed 19519 respondents (~ 66% female) with participants' ages ranging from 18 to 89 years and an average age of 27.87 years. Data for all demographic variables followed a normal distribution. Further descriptive statistics relating to age, weight, height and gender can be found in Table 1.

BMR and personality – Domain level

Significant Spearman's rhos were found between BMR and all domains apart from *conscientiousness*. All correlations were relatively small ($r = -0.04 \dots 0.02$) (Table 2).

Table 1
Descriptive Statistics of the Final Sample

	Mean	SD	Min	Max	Range
Females (n= 12805)					
Height	164.09	7.11	142.0	185.0	43.0
Weight	69.30	17.01	36.3	126.1	89.8
Age	28.05	11.40	18.0	80.0	62.0
Males (n=6714)					
Height	178.99	7.44	157.0	201.0	44.0
Weight	84.54	18.82	42.2	136.1	93.9
Age	27.53	11.14	18.0	89.0	71.0

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BMR and personality – Facet level

Of the 30 facets within the IPIP-NEO, only two showed a statistically significant relationship with BMR (Table 2). The positive correlation with *N5: Immoderation* facet ($r = .22$) indicates that BMR shared around 5% of this items variance, while BMR had a small negative correlation with *O6: Liberalism* ($r = -.08$). The correlation of *E4: Activity Level* with BMR was small and non-significant ($r = -.03$). None of the items within this facet correlated significantly with BMR. The remaining facets also showed no significant relationship with BMR.

BMR and personality – Item level

Looking at the two statistically significant facets in more detail, it was found that almost all items within the *N5: Immoderation* facet had a statistically significant relationship with BMR (Table 3). Spearman's rhos were also both positive and in some cases, moderately large ($r = 0.06...0.37$). The item with the largest correlation was "Often eat too much" and BMR shared almost 14% of this item's variance. The item with the second largest correlation was "Am able to control my cravings". BMR shared almost 3% of this item's variance. Both positively worded items and reverse scored items in this facet found significant and moderately strong correlations with BMR.

Five items within the facet *O6: Liberalism* also showed moderate to weak negative correlations with BMR ($r = -0.13...-0.07$) that were also statistically significant (Table 4). The item with the strongest negative correlation was "Like to stand during the national anthem" and BMR shared 1.6% of variance with this item.

N5: Immoderation vs. weight and height

To investigate the separate contributions of height and weight to items of this facet, Spearman's rhos were found between weight, height and *N5: Immoderation* items. Residualised weight data correlated in a very similar way to that of BMI (Table 3) but for most items in this facet, the relationships between items and weight was actually stronger than it was with BMR. The item with the strongest correlation was again "Often eat too much". In this case, weight could explain 17.6% of this item's variance. Height did not significantly correlate with any items in this facet and so these results have not been reported.

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Table 2
Correlations Between Personality Traits and BMR

	rho	df
Neuroticism	.02*	11908
Extraversion	.02*	12389
Openness	-0.04***	13669
Agreeableness	-0.02*	14636
Conscientiousness	-0.01	14169
N1: Anxiety	-0.01	2050
N2: Anger	.04	1942
N3: Depression	.03	2074
N4: Self-Consciousness	-0.02	2144
N5: Immoderation	.22***	2110
N6: Vulnerability	-0.02	2048
E1: Friendliness	.01	2295
E2: Gregariousness	.01	2081
E3: Assertiveness	.03	3080
E4: Activity Level	-0.03	2051
E5: Excitement-Seeking	-0.01	1968
E6: Cheerfulness	.04	2134
O1: Imagination	-0.01	2096
O2: Artistic Interests	-0.03	2072
O3: Emotionality	-0.04	2394
O4: Adventurousness	-0.02	2011
O5: Intellect	-0.03	3580
O6: Liberalism	-0.08**	2016

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	rho	df
A1: Trust	.03	2038
A2: Morality	-0.03	4620
A3: Altruism	-0.01	2717
A4: Cooperation	-0.03	2160
A5: Modesty	.03	2375
A6: Sympathy	-0.05	2169
C1: Self-Efficacy	.03	2058
C2: Orderliness	-0.01	3890
C3: Dutifulness	-0.03	2396
C4: Achievement- Striving	-0.04	2310
C5: Self-Discipline	-0.03	2029
C6: Cautiousness	-0.02	2323

Note. Personality and BMR have been residualised for age, age-squared and sex. All *p*-values are adjusted for false discovery rate.

p* < .05, *p* < .01, ****p* < .001

O6: Liberalism vs weight and height

Following the pattern of the *N5:Immoderation* facet items, weight had significant relationships with almost all items in this facet (Table 3). Rhos were moderately weak ($r = -0.13 \dots -0.06$) and were very similar to the correlations with BMR. Height did not correlate significantly with any of these items.

Height and Assertiveness

Height correlated significantly with the *E3: Assertiveness* facet ($r = 0.06$, $p < 0.05$) and significant correlations were found with two items that belong to this facet. They were “Take charge” ($r = 0.07$, $p < 0.01$) and “Keep in the background” ($r = 0.07$, $p < 0.05$). Height was also found to correlate significantly with the *A2: Morality* facet but this relationship was not further investigated.

*Personality, basal metabolic rate, height and weight*Table 3: *N5:Immoderation* correlations with BMR and weight

N5: Immoderation Items	BMR (rho)	Weight (rho)	df
Often eat too much.	.37***	.42***	2068
Am able to control my cravings.	.17***	.19***	2011
Rarely overindulge.	.16***	.18***	2058
Love to eat.	.11***	.13***	2080
Go on binges.	.10***	.10***	2097
Never spend more than I can afford.	.10***	.12***	2088
Easily resist temptations.	.09**	.09***	2046
Don't know why I do some of the things I do.	.07*	.07*	2225
Never splurge.	.06*	.07**	2103
Do things I later regret.	.02	.03	2098

Notes: Personality and BMR variables have been residualised for age, age-squared and sex. All p-values are adjusted for false discovery rate.

*p< .05, **p< .01, ***p< .001

Table 4: *O6: Liberalism* correlations with BMR and weight

Liberalism (O6) Items	BMR (rho)	Weight (rho)	df
Like to stand during the national anthem.	-0.13***	-0.13***	2112
Believe that we coddle criminals too much.	-0.08***	-0.10***	2075
Believe laws should be strictly enforced.	-0.08***	-0.09***	2021
Believe that we should be tough on crime.	-0.07*	-0.08***	2058
Tend to vote for liberal political candidates.	-0.07*	-0.08***	2007
Believe that criminals should receive help rather than punishment.	-0.06	-0.07**	2083
Believe in one true religion.	.06	-0.07*	2054
Believe that there is no absolute right and wrong.	-0.06	-0.06*	1995
Believe that too much tax money goes to support artists.	0	.01	1965
Tend to vote for conservative political candidates.	-0.02	-0.01	2007

Notes: Personality and BMR variables have been residualised for age, age-squared and sex. All p-values are adjusted for false discovery rate.

*p< .05, **p< .01, ***p< .001, df = n-2

4. DISCUSSION

Animal studies have demonstrated that clear but complicated associations exist between behaviour, personality, size and measures of metabolism. Research looking at similar relationships in humans is however quite limited. This study's general aim was to explore associations between personality and variables such as basal metabolic rate, height and weight. To do this, data within a very large, publicly available database was analysed. The database contained self-reported measures of height, weight, age and sex as well as responses to IPIP-NEO personality inventory items. Despite possible problems related to the quality of information contained in this database, it provided a valuable opportunity for statistical relationships to be investigated between these factors.

It was found that BMR was significantly related with almost all IPIP-NEO domains (except *conscientiousness*) although correlations were weak. This somewhat contrasts with previous studies where BMR was found to either be uncorrelated with personality traits (Terracciano et al., 2013) or to have significant correlations with one or two domains (Arumäe et al., 2022; Bergeron et al., 2021). Arumäe and colleagues (2022) suggested that previous studies may have suffered from small sample sizes. The large size of the sample used within this study may have helped to strengthen correlations found at the domain level.

When looking at facet level results, associations with BMR became narrower and stronger. Only two out of 30 facets had significant correlations with BMR. The *N5: Immoderation* facet had a relatively strong correlation with BMR while the *O6: Liberalism* facet showed a relatively weak correlation. This again contrasts with previous work where assertiveness was the only facet found to be reliably linked with BMR (Arumäe et al., 2022).

The neuroticism facet *N5:Immoderation* has been linked to overeating and obesity (e.g. Heaven et al., 2001; Vainik et al., 2019) . Johnson (n.d.) describes people scoring high on this facet as being oriented towards impulsivity, short-term pleasures and having trouble resisting urges. Most of these *N5: Immoderation* facet items were significantly and positively correlated with BMR and the item „Often eat too much” had the strongest correlation with BMR. Speculation that these item scores may be connected with overeating are supported by separate correlations with the weight variable – an important component of BMR. It was found that weight was even more strongly correlated with these items than BMR. In comparison, height - another important BMR component- showed no significant correlations. Why is it then, that weight seems to be a much more important factor than height in how BMI

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correlates with these items. It is possible that the sample was somehow dominated by highly muscular persons lacking self-control in regards to eating. It is however more likely that overeating has contributed to adiposity, which in turn is affecting measures of BMR. This suggests that the accuracy of the Mifflin-St Jeor equation may be sensitive to higher levels of adiposity. Interestingly, the results of Arumäe et al. (2022) show that BMR, body mass index and relative fat mass (RFM) were all significantly and reasonably strongly correlated with the *N5: Impulsivity* facet of the NEO-PI-R (which is equivalent with *N5: Immoderation* of the IPIP-NEO).

The *O6: Liberalism* facet belongs to the *Openness* domain but it could be speculated that the small, negative but significant correlation between BMR, weight and the *O6: Liberalism* facet may also be related to adiposity, particularly as this facet didn't correlate with height. Although there is limited evidence in the literature directly linking the *Openness* domain and obesity (e.g. Jokela et al., 2013) studies relating to eating habits (e.g. reviewed by Lunn et al., 2014) have shown that lower levels of *Openness* are associated with a poorer diet - e.g. high in convenience foods but low in fruits and vegetables – which in itself is a risk factor for obesity. This may mean that people who are more conservative are also less open to healthier ways of eating. This may result in an increased level of adiposity which may in turn be driving the association with BMR. However, as Lunn and colleagues (2014) note, healthier diets are also more prevalent in wealthier and better educated populations, so these associations may also be mediated by sociocultural factors not investigated in this study.

In regards to the relationship between height and assertiveness, a weak but positive and significant correlation was found between height and two items in the *E3: Assertiveness* facet. Studies of non-human animal behaviour have identified that larger individuals tend to behave more dominantly. The findings of this study weakly support the possibility that assertive behaviour may be more common amongst taller people. It has also been found in non-human animal studies, that individuals with higher rates of basal metabolism tend to also be more active. This study however provided no evidence to support this link in humans.

Taken together, this exploration discovered evidence of mostly small but also statistically significant relationships between BMR, weight, height and personality. The strongest correlations found suggest that BMR, weight and impulsiveness are interrelated. To better understand these results, it would be beneficial to further explore the SAPA database. Other data available in this database, such as respondents BMI, education level and exercise

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regularity could be used to better parse the interrelations between personality, weight, height and BMR. Similar analyses could also be performed using data of other national cohorts (e.g. The United Kingdom) not analysed in this study. This may provide informative comparisons with the USA sample.

5. REFERENCES

- Arumäe, K., Möttus, R., & Vainik, U. (2022). Beyond BMI: Personality traits' associations with adiposity and metabolic rate. *Physiology & Behavior*, 246, 113703. <https://doi.org/10.1016/j.physbeh.2022.113703>
- Benjamini, Y., & Hochberg, Y. (1995). Controlling the False Discovery Rate: A Practical and Powerful Approach to Multiple Testing. *Journal of the Royal Statistical Society: Series B (Methodological)*, 57(1), 289–300. <https://doi.org/10.1111/j.2517-6161.1995.tb02031.x>
- Bergeron, P., Pagé, A., & Trempe, M. (2021). Integrating humans into pace-of-life studies: The Big Five personality traits and metabolic rate in young adults. *PLoS ONE*, 16(4). <https://doi.org/10.1371/journal.pone.0248876>
- Biro, P. A., Garland, T., Beckmann, C., Ujvari, B., Thomas, F., & Post, J. R. (2018). Metabolic Scope as a Proximate Constraint on Individual Behavioral Variation: Effects on Personality, Plasticity, and Predictability. *The American Naturalist*, 192(2), 142–154. <https://doi.org/10.1086/697963>
- Biro, P. A., & Stamps, J. A. (2010). Do consistent individual differences in metabolic rate promote consistent individual differences in behavior? *Trends in Ecology & Evolution*, 25(11), 653–659. <https://doi.org/10.1016/j.tree.2010.08.003>
- Boratyński, Z. (2020). Energetic constraints on mammalian home-range size. *Functional Ecology*, 34(2), 468–474. <https://doi.org/10.1111/1365-2435.13480>
- Careau, V., Thomas, D., Humphries, M. M., & Réale, D. (2008). Energy metabolism and animal personality. *Oikos*, 117(5), 641–653. <https://doi.org/10.1111/j.0030-1299.2008.16513.x>
- Condon, D. M., Roney, E., & Revelle, W. (2017). A SAPA Project Update: On the Structure of phrased Self-Report Personality Items. *Journal of Open Psychology Data*, 5(1), 3. <https://doi.org/10.5334/jopd.32>
- Cutts, C. J., Metcalfe, N. B., & Taylor, A. C. (1998). Aggression and growth depression in juvenile Atlantic salmon: The consequences of individual variation in standard metabolic rate. *Journal of Fish Biology (United Kingdom)*.
- DeYoung, C. G. (2010). Personality Neuroscience and the Biology of Traits. *Social and Personality Psychology Compass*, 4(12), 1165–1180. <https://doi.org/10.1111/j.1751-9004.2010.00327.x>
- Eysenck, H.J. (1952). *The scientific study of personality*. Routledge & K. Paul, London

Personality, basal metabolic rate, height and weight

- Eysenck, S. B. G., Eysenck, H. J., & Barrett, P. (1985). A revised version of the psychoticism scale. *Personality and Individual Differences*, 6(1), 21–29. [https://doi.org/10.1016/0191-8869\(85\)90026-1](https://doi.org/10.1016/0191-8869(85)90026-1)
- Fryar, C.D., Carroll, M.D., Gu, Q, Afful, J. & Ogden, C.L. (2021). Anthropometric reference data for children and adults: United States, 2015–2018. National Center for Health Statistics. *Vital Health Stat* 3(46).
- Goldberg, L. R. (1999) A broad-bandwidth, public domain, personality inventory measuring the lower-level facets of several five-factor models. In Mervielde, I., Deary, I., De Fruyt, F., Ostendorf, F. (Eds.). *Personality Psychology in Europe, Vol. 7.* (pp. 7-28). Tilburg University Press.
- Goldberg, L. R., Johnson, J. A., Eber, H. W., Hogan, R., Ashton, M. C., Cloninger, C. R., & Gough, H. G. (2006). The international personality item pool and the future of public-domain personality measures. *Journal of Research in Personality*, 40(1), 84–96. <https://doi.org/10.1016/j.jrp.2005.08.007>
- Goldstein, I. B. (1964). Role of muscle tension in personality theory. *Psychological Bulletin*, 61(6), 413–425. <https://doi.org/10.1037/h0040472>
- Gębczyński, A. K., & Konarzewski, M. (2009). Locomotor activity of mice divergently selected for basal metabolic rate: A test of hypotheses on the evolution of endothermy. *Journal of Evolutionary Biology*, 22(6), 1212–1220. <https://doi.org/10.1111/j.1420-9101.2009.01734.x>
- Haig, B. D. (2005). Exploratory Factor Analysis, Theory Generation, and Scientific Method. *Multivariate Behavioral Research*, 40(3), 303–329. https://doi.org/10.1207/s15327906mbr4003_2
- Hasson, R. E., Howe, C. A., Jones, B. L., & Freedson, P. S. (2011). Accuracy of four resting metabolic rate prediction equations: Effects of sex, body mass index, age, and race/ethnicity. *Journal of Science and Medicine in Sport*, 14(4), 344–351. <https://doi.org/10.1016/j.jsams.2011.02.010>
- Heaven, P. C. L., Mulligan, K., Merrilees, R., Woods, T., & Fairouz, Y. (2001). Neuroticism and conscientiousness as predictors of emotional, external, and restrained eating behaviors. *International Journal of Eating Disorders*, 30(2), 161–166. <https://doi.org/10.1002/eat.1068>
- Iacobucci, D., Schneider, M. J., Popovich, D. L., & Bakamitsos, G. A. (2016). Mean centering helps alleviate “micro” but not “macro” multicollinearity. *Behavior Research Methods*, 48(4), 1308–1317. <https://doi.org/10.3758/s13428-015-0624-x>

IPIP Home. (n.d.). Retrieved 6 May 2021, from <https://ipip.ori.org/>

Johnson, J. A. (n.d.). *Descriptions used in IPIP-NEO narrative report.*

<http://www.personal.psu.edu/faculty/j/5/j5j/IPIPNEOdescriptions.html> Accessed April 24, 2022.

Jokela, M., Hintsanen, M., Hakulinen, C., Batty, G. D., Nabi, H., Singh-Manoux, A., & Kivimäki, M. (2013). Association of personality with the development and persistence of obesity: A meta-analysis based on individual-participant data. *Obesity Reviews, 14*(4), 315–323. <https://doi.org/10.1111/obr.12007>

Jorm, A. F., & Christensen, H. (2004a). Religiosity and personality: Evidence for non-linear associations. *Personality and Individual Differences, 36*(6), 1433–1441.

[https://doi.org/10.1016/S0191-8869\(03\)00239-3](https://doi.org/10.1016/S0191-8869(03)00239-3)

Josefsson, K., Cloninger, C. R., Hintsanen, M., Jokela, M., Pulkki-Råback, L., & Keltikangas-Järvinen, L. (2011). Associations of personality profiles with various aspects of well-being: A population-based study. *Journal of Affective Disorders, 133*(1), 265–273.

<https://doi.org/10.1016/j.jad.2011.03.023>

Kaplan, D., & Su, D. (2018). On imputation for planned missing data in context questionnaires using plausible values: A comparison of three designs. *Large-Scale Assessments in Education, 6*(1), 6. <https://doi.org/10.1186/s40536-018-0059-9>

Kemp, A. H., Quintana, D. S., Gray, M. A., Felmingham, K. L., Brown, K., & Gatt, J. M. (2010). Impact of Depression and Antidepressant Treatment on Heart Rate Variability: A Review and Meta-Analysis. *Biological Psychiatry, 67*(11), 1067–1074.

<https://doi.org/10.1016/j.biopsych.2009.12.012>

Koelsch, S., Enge, J., & Jentschke, S. (2012). Cardiac Signatures of Personality. *PLOS ONE, 7*(2), e31441. <https://doi.org/10.1371/journal.pone.0031441>

Lahti, M., Räikkönen, K., Lemola, S., Lahti, J., Heinonen, K., Kajantie, E., Pesonen, A.-K., Osmond, C., Barker, D. J. P., & Eriksson, J. G. (2013). Trajectories of physical growth and personality dimensions of the Five-Factor Model. *Journal of Personality and Social Psychology, 105*(1), 154–169. <https://doi.org/10.1037/a0032300>

Lunn, T. E., Nowson, C. A., Worsley, A., & Torres, S. J. (2014). Does personality affect dietary intake? *Nutrition, 30*(4), 403–409. <https://doi.org/10.1016/j.nut.2013.08.012>

Mailhos, A., Buunk, A. P., & del Arca, D. (2017). High intrasexual competition is related to inflated height reports in male junior soccer players. *Personality and Individual Differences, 113*, 229–234. <https://doi.org/10.1016/j.paid.2017.03.030>

- Maples, J. L., Guan, L., Carter, N. T., & Miller, J. D. (2014). A test of the International Personality Item Pool representation of the Revised NEO Personality Inventory and development of a 120-item IPIP-based measure of the five-factor model. *Psychological Assessment, 26*(4), 1070–1084. <https://doi.org/10.1037/pas0000004>
- Margolis, S., Stapley, A. L., & Lyubomirsky, S. (2020). The association between Extraversion and well-being is limited to one facet. *Journal of Personality, 88*(3), 478–484. <https://doi.org/10.1111/jopy.12504>
- Mathot, K. J., Dingemanse, N. J., & Nakagawa, S. (2019). The covariance between metabolic rate and behaviour varies across behaviours and thermal types: Meta-analytic insights. *Biological Reviews, 94*(3), 1056–1074. <https://doi.org/10.1111/brv.12491>
- Mauss, I. B., & Robinson, M. D. (2009). Measures of emotion: A review. *Cognition and Emotion, 23*(2), 209–237. <https://doi.org/10.1080/02699930802204677>
- McClune, D. W., Kostka, B., Delahay, R. J., Montgomery, W. I., Marks, N. J., & Scantlebury, D. M. (2015). Winter Is Coming: Seasonal Variation in Resting Metabolic Rate of the European Badger (*Meles meles*). *PLOS ONE, 10*(9), e0135920. <https://doi.org/10.1371/journal.pone.0135920>
- McCrae, R. R. (2015). A More Nuanced View of Reliability: Specificity in the Trait Hierarchy. *Personality and Social Psychology Review, 19*(2), 97–112. <https://doi.org/10.1177/1088868314541857>
- McCrae, R. R., & John, O. P. (1992). An Introduction to the Five-Factor Model and Its Applications. *Journal of Personality, 60*(2), 175–215. <https://doi.org/10.1111/j.1467-6494.1992.tb00970.x>
- Melamed, T. (1992). Personality correlates of physical height. *Personality and Individual Differences, 13*(12), 1349–1350. [https://doi.org/10.1016/0191-8869\(92\)90179-S](https://doi.org/10.1016/0191-8869(92)90179-S)
- Mifflin, M. D., St Jeor, S. T., Hill, L. A., Scott, B. J., Daugherty, S. A., & Koh, Y. O. (1990). A new predictive equation for resting energy expenditure in healthy individuals. *The American Journal of Clinical Nutrition, 51*(2), 241–247. <https://doi.org/10.1093/ajcn/51.2.241>
- Montepare, J. M. (1995). The impact of variations in height on young children's impressions of men and women. *Journal of Nonverbal Behavior, 19*(1), 31–47. <https://doi.org/10.1007/BF02173411>

- Möttus, R., Kandler, C., Bleidorn, W., Riemann, R., & McCrae, R. R. (2017). Personality traits below facets: The consensual validity, longitudinal stability, heritability, and utility of personality nuances. *Journal of Personality and Social Psychology*, *112*(3), 474–490. <https://doi.org/10.1037/pspp0000100>
- Möttus, R., & Rozgonjuk, D. (2021). Development is in the details: Age differences in the Big Five domains, facets, and nuances. *Journal of Personality and Social Psychology*, *120*(4), 1035–1048. <https://doi.org/10.1037/pspp0000276>
- Nimbarte, A. D., Al Hassan, M. J., Guffey, S. E., & Myers, W. R. (2012). Influence of psychosocial stress and personality type on the biomechanical loading of neck and shoulder muscles. *International Journal of Industrial Ergonomics*, *42*(5), 397–405. <https://doi.org/10.1016/j.ergon.2012.05.001>
- Ones, D. S., Viswesvaran, C., & Reiss, A. D. (1996). Role of social desirability in personality testing for personnel selection: The red herring. *Journal of Applied Psychology*, *81*(6), 660–679. <https://doi.org/10.1037/0021-9010.81.6.660>
- Paunonen, S. V., & Ashton, M. C. (2001). Big Five factors and facets and the prediction of behavior. *Journal of Personality and Social Psychology*, *81*(3), 524–539. <https://doi.org/10.1037/0022-3514.81.3.524>
- Paunonen, S. V., Haddock, G., Forsterling, F., & Keinonen, M. (2003). Broad versus narrow personality measures and the prediction of behaviour across cultures. *European Journal of Personality*, *17*(6), 413–433. <https://doi.org/10.1002/per.496>
- RStudio Team (2022). *RStudio: Integrated Development Environment for R*. RStudio, PBC, Boston, MA <http://www.rstudio.com/>.
- Revelle, W., Dworak, E. M., & Condon, D. M. (2021). Exploring the persome: The power of the item in understanding personality structure. *Personality and Individual Differences*, *169*, 109905. <https://doi.org/10.1016/j.paid.2020.109905>
- Schmitt, D. P., Allik, J., McCrae, R. R., & Benet-Martínez, V. (2007). The Geographic Distribution of Big Five Personality Traits: Patterns and Profiles of Human Self-Description Across 56 Nations. *Journal of Cross-Cultural Psychology*, *38*(2), 173–212. <https://doi.org/10.1177/0022022106297299>
- Stulp, G., Buunk, A. P., Verhulst, S., & Pollet, T. V. (2015). Human Height Is Positively Related to Interpersonal Dominance in Dyadic Interactions. *PLOS ONE*, *10*(2), e0117860. <https://doi.org/10.1371/journal.pone.0117860>

Personality, basal metabolic rate, height and weight

- Terracciano, A., Sutin, A. R., McCrae, R. R., Deiana, B., Ferrucci, L., Schlessinger, D., Uda, M., & Costa, P. T. J. (2009). Facets of Personality Linked to Underweight and Overweight. *Psychosomatic Medicine*, *71*(6), 682–689.
<https://doi.org/10.1097/PSY.0b013e3181a2925b>
- Terracciano, A., Schrack, J. A., Sutin, A. R., Chan, W., Simonsick, E. M., & Ferrucci, L. (2013). Personality, Metabolic Rate and Aerobic Capacity. *PLoS ONE*, *8*(1).
<https://doi.org/10.1371/journal.pone.0054746>
- Trobst, K. K., Herbst, J. H., Masters, H. L., & Costa, P. T. (2002). Personality Pathways to Unsafe Sex: Personality, Condom Use, and HIV Risk Behaviors. *Journal of Research in Personality*, *36*(2), 117–133. <https://doi.org/10.1006/jrpe.2001.2334>
- Undurraga, E. A., Zebrowitz, L., Eisenberg, D. T. A., Reyes-García, V., Team, T. B. S., & Godoy, R. A. (2012). The Perceived Benefits of Height: Strength, Dominance, Social Concern, and Knowledge among Bolivian Native Amazonians. *PLOS ONE*, *7*(5), e35391. <https://doi.org/10.1371/journal.pone.0035391>
- Vainik, U., Möttus, R., Allik, J., Esko, T., & Realo, A. (2015). Are Trait–Outcome Associations Caused by Scales Or Particular Items? Example Analysis of Personality Facets and Bmi. *European Journal of Personality*, *29*(6), 622–634.
<https://doi.org/10.1002/per.2009>
- Vainik, U., Dagher, A., Realo, A., Colodro-Conde, L., Mortensen, E. L., Jang, K., Juko, A., Kandler, C., Sørensen, T. I. A., & Möttus, R. (2019). Personality-obesity associations are driven by narrow traits: A meta-analysis. *Obesity Reviews*, *20*(8), 1121–1131.
<https://doi.org/10.1111/obr.12856>
- Zohar, A. H., Cloninger, C. R., & McCraty, R. (2013). Personality and Heart Rate Variability: Exploring Pathways from Personality to Cardiac Coherence and Health. *Open Journal of Social Sciences*, *01*(06), 32. <https://doi.org/10.4236/jss.2013.16007>

APPENDIX 1

IPIP-NEO Domain descriptive statistics

Domain	n	mean	sd	min	max
N	11910	3,38	0,92	1	6
E	12391	3,88	0,83	1	6
O	13671	4,3	0,75	1	6
A	14638	4,3	0,74	1	6
C	14171	4,31	0,77	1,17	6

IPIP-NEO Facet descriptive statistics

Facet	n	mean	sd	min	max
N1: Anxiety	2052	3,58	1,17	1	6
N2: Anger	1944	3,25	1,17	1	6
N3: Depression	2076	3,22	1,31	1	6
N4: Self-Consciousness	2146	3,52	1,12	1	6
N5: Immoderation	2112	3,79	0,99	1	6
N6: Vulnerability	2050	3,09	1,12	1	6
E1: Friendliness	2297	3,98	1,15	1	6
E2: Gregariousness	2083	3,21	1,21	1	6
E3: Assertiveness	3082	3,92	1,05	1	6
E4: Activity Level	2053	3,46	0,91	1	6
E5: Excitement-Seeking	1970	3,59	1,11	1	6
E6: Cheerfulness	2136	4,4	0,99	1	6
O1: Imagination	2098	4,62	0,98	1	6
O2: Artistic Interests	2074	4,8	0,97	1	6
O3: Emotionality	2396	4,51	0,95	1	6
O4: Adventurousness	2013	4,08	0,96	1	6
O5: Intellect	3582	4,54	1,04	1	6
O6: Liberalism	2018	3,76	1,2	1	6
A1: Trust	2040	3,85	1,07	1	6
A2: Morality	4622	4,58	0,96	1	6
A3: Altruism	2719	4,76	0,88	1,2	6
A4: Cooperation	2162	4,19	1	1	6
A5: Modesty	2377	3,75	1,01	1	6
A6: Sympathy	2171	4,29	0,99	1	6
C1: Self-Efficacy	2060	4,59	0,83	1,25	6
C2: Orderliness	3892	4,03	1,08	1	6
C3: Dutifulness	2398	4,75	0,83	1	6
C4: Achievement-Striving	2312	4,6	0,89	1,25	6
C5: Self-Discipline	2031	3,58	1,15	1	6
C6: Cautiousness	2325	3,91	1,02	1	6

Personality, basal metabolic rate, height and weight

Käesolevaga kinnitan, et olen korrektselt viidanud kõigile oma töös kasutatud teiste autorite poolt loodud kirjalikele töödele, lausetele, mõtetele, ideedele või andmetele.

Olen nõus oma töö avaldamisega Tartu Ülikooli digitaalarhiivis DSpace.

Geoffrey Longhurst