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What Are the Biological Effects Behind the Impact of Social Isolation?

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ABSTRACT

In this paper, we sought to understand the biological effects in the human body when a person experiences social isolation, so that we can have a better understanding of these and recognize the steps needed to reduce the severity of their biological impacts. Previous research has predicted the biological effects of social isolation by variables such as the levels of blood pressure, testosterone, food intake, and hippocampal functioning. In our correlational study, we tested the strength of these relationships by examining naturalistic daily changes in their variables longitudinally over a two-week period. We measured blood pressure levels using an electronic blood pressure monitor, inferred the amount of food intake by counting the amount of calories consumed, inferred testosterone levels based on measured leg hair growth rates, measured hippocampal functioning by performance on a spatial memory test, and determined the level of social isolation by using a scale. Data pooled across participants in our correlational study showed significant correlations of social isolation with systolic blood pressure, but not with calorie intake, testosterone levels or hippocampal functioning.

1. Introduction

1.1 Research Problem

Social isolation is one of the many reasons for deteriorating mental health among us today. It has the potential to cause anxiety, stress, depression, sleep deprivation and persistent thoughts about self-harm. Those who are socially isolated may lose important connections such as their family members, friends, or loved ones, which can make recovery long and painful, physically as well as mentally. We wish to know more about how the human body responds to social isolation and the potential shifts in behaviour.

1.2 Literature Review

A most significant physical symptom found behind the impact of social isolation is increased systolic blood pressure. In an experiment by Shankar et al. (2011), social isolation was measured by a point system (ranging from zero to five, with higher scores indicating greater social isolation) to compute levels of social isolation. One point was given to participants if they did not have a partner, another point if they had less than monthly contact with children, family and friends (each scored separately), and another point if they did not engage in any organizations, religious associations, and committees. Participants selected were individuals born on or before February 2, 1952 who contributed to the Health Survey for England in 1998, 1999, or 2011 and were selected by the English Longitudinal Study of Ageing. Then in 2004, the participants were checked regularly by nurses for systolic blood pressure measurement and blood sampling, except from participants with hematologic disorders. It was shown that increases in social isolation were associated with increases of systolic blood pressure. Based on these results, social isolation appears to lead to reduced cardiovascular health.

Another factor previously found to be affected by social isolation islowered intake of food. An experiment conducted by Grippo et al. (2007) on 15 adult female prairie voles (a species that display social behavior similar to humans) revealed that social isolation of prairie voles for 4 weeks caused a lower intake of sucrose. There were 7 prairie voles in the isolated experimental group and 8 prairie voles were paired with siblings in the control group. Everything else was kept the same for the groups except that in the experimental group there was only one member in each cage. The findings showed that sucrose intake was reduced in the experimental group throughout the 4 weeks period of isolation as compared to prairie voles in the control group.

An important question that has arisen among researchers is whether testosterone levels have any association with social isolation. The study by Havashi et al.(2020) had a total of 159 adolescent boys who were divided into 5 groups, from the lowest level of testosterone group to the highest. Based on measurements of their social withdrawal, social isolation was found to be associated with decreases in testosterone levels.

In addition to the effects of social isolation on mental health, a study was conducted on a particular line of rats to assess if running exercise attenuates the effects of social isolation. In an experiment by Gómez-Galán & Femenía (2016), for a total of five weeks rats were divided into three groups: the first group were housed with 3–4 rats per cage, the second group were individually housed rats, and the third group were individually housed rats given free access to a running wheel. After the 5 weeks, the animals were then given anesthetics, and humanely decapitated in order to analyze the hippocampus, a part of the brain is responsible for spatial memory and navigation. It was found that social isolation caused a decrease in hippocampus size and that exercise could not attenuate these effects. Based on these results, it can be concluded that the effects of social isolation leads to smaller than normal hippocampi with the possibility of irreversible cognitive consequences.

1.3 Hypotheses

Based on the above literature review, we predicted the following hypothesis:

- Hypothesis #1: If social isolation increases then systolic blood pressure will increase.
- Hypothesis #2: If social isolation increases then the amount of sugar consumed will increase.
- Hypothesis #3: If social isolation increases then the level of testosterone will decrease.
- Hypothesis #4: If social isolation increases then hippocampal functioning will decrease.

2. Methods

2.1 Participants

The four authors of this paper served as the participants in its studies. The participants ranged in age from 19 to 24 years old, with an average age of 21, and included three women and one man. The participants were all undergraduate students at Camosun College who completed the current studies as an assignment for Psyc 215 ("Biological Psychology") and were grouped together due to their mutual interest in the biological effects of social isolation. All of the participants were in social isolation due to the COVID-19 pandemic.

2.2 Materials and Procedure

We performed a correlational study to test concurrently all four of our hypotheses by examining naturalistic daily changes in their variables longitudinally. Each participant kept a study journal with them at all times over this study's two-week period in order to record self-observations of the following five variables: (1) systolic blood pressure, (2) intake of food, (3) testosterone , (4) hippocampal functioning, and (5) social isolation.

To measure the levels of blood pressure, each participant recorded their blood pressure by using an electronic blood pressure monitor every day. At least 80% of the upper arm was wrapped with the inflatable cuff and placed on bare skin, not over any clothing. The participants had the blood pressure measured twice, with a small pause in between; if the readings were different by 5 points or more, then they had it done a third time. To ensure a correct reading, the participants made sure to have an empty bladder 30 minutes prior taking their blood pressureand did not consume any caffeinated beverages or smoke. Five minutes before the measurement the participants sat quietly and they remained silent during measurement.

To measure the amount of food participants consumed in a day, they had tracked the number of calories in their food that they consumed using an online app named "Cronometer". At the end of each day, participants reported the total number of calories they had consumed from the food.

In order to measure the level of testosterone, we measured the leg hair growth of the participants every day for two weeks. Each leg was divided into four circular samples of radius 4 cm, located in the center of the thigh, behind the thigh, in the center of the shin and in the center calf; thus having a total number of 16 samples each day. An average was calculated of the leg hair growth across the four leg areas measured. For this experiment a razor will be used; once the hairs are shaved, the hair growth of the chosen regions will be measured daily with a ruler.

To measure hippocampal functioning, each participant completed a memory-span task called the "Corsi Block Tapping" task, which assesses spatial memory ability. For the task, participants created an online profile on the BrainScale website (https://brainscale.net/corsi) where they were instructed to partake in an exercise—they watched 5 blocks appear on their screen and then were asked to remember the order the blocks had appeared, so that they could repeat it back to the best of their ability. The exercise lasted 4 rounds, and then gave the final results once completed. For these records, participants wrote down the time it took them to complete the task (seconds), the percent of accuracy (%), their score maximum (max), and lastly their score average (avg). Each day for this study participants recorded their results.

To measure the social isolation levels, every night participants used a method similar to the one used by Shankar et al (2011). The method involves calculating social isolation with a numerical scale from zero to five, with higher score suggesting greater social isolation. Participants counted the amount of social interaction daily, one point was granted to participants, if they did not have a partner; had less interaction with children, families, and friends (each scored as one) – and lastly if they did not participate in any classes, groups, religious societies, or committees (scored as one).

To assess the strength and statistical significance of associations between variables predicted by our four hypotheses, we performed Pearson product moment correlations of their predictor variables (blood pressure, intake of food, depression , and spatial memory) with their outcome variable (social isolation). For testing Hypothesis #1, we correlated the level of systolic blood pressure with the social isolation rating. For testing Hypothesis #2, we correlated the amount of calories consumed with the social isolation rating. For testing Hypothesis #3, we correlated the levels of leg hair growth with the social isolation rating. For testing Hypothesis #4, we correlated the spatial memory score with the social isolation rating. We performed all of the above correlations separately for each participant as well as using data pooled across all of the participants. For the correlations using pooled data, in addition to using the raw data, we also performed correlations after we had first transformed the data from each participant into *z*-scores in order to standardize differences in averages and variability seen between the participants in their data and thus make them more comparable. A correlation coefficient was considered statistically significant if the probability of its random occurrence (p) was $< .05$ (i.e., less than 5% of the time expected by chance alone).

3. Results

As shows in Table 1, systolic blood pressure level was significantly correlated with social isolation levels. While not statistically significant for Participant #2 ($r = .45$, $p = .10$), it was statistically significant for the three other participants (for Participants #1, 3, & 4, all $r \leq .75$ and all $p \leq .001$), and with systolic blood pressure level being significantly correlated with social isolation level using both pooled raw data ($r = 0.59$, p = 7.73e-07; see Figure 1A) and pooled standardized data ($r = 0.71$, p =9.45e-11 ; see Figure 1B). In contrast, no statistically significant correlations were found between calorie intake, testosterone levels, spatial memory, and social isolation levels using any single participant's data (all $r \geq .48$, all $p \geq .08$). Calorie intake was not significantly correlated with social isolation using either the pooled raw data (r =-.06, p =.67 ; see Figure 2A) or the pooled standardized data (r =.16 , p =.24 ; see Figure 2B). Testosterone levels were not significantly correlated with social isolation using either the pooled raw data (r =.01, p =.95; see Figure 3A) or the pooled standardized data (r =.08, p =0.53; see Figure 3B). Spatial memory was not significantly correlated with social isolation using either the pooled raw data (r =-.03, p = .82; see Figure 4A) or the pooled standardized data (r =-.06, p =.65; see Figure 4B). Based on a comparison of the correlation coefficient using either pooled raw data or the pooled standardize data, systolic blood pressure showed the strongest correlation with social isolation.

4. Discussion

4.1 Summary of Results

Based on previous research, we hypothesized that increases in two variables would be followed by higher levels of social isolation; the systolic blood pressure level (Hypothesis #1), and the calorie intake (Hypothesis #2). We hypothesized that decreases in two variables would be followed by higher levels of social isolation; testosterone levels (Hypothesis #3), and hippocampus activity (Hypothesis #4). Data pooled across participants in our correlational study supported the predicted relationship of systolic blood pressure and social isolation level (Hypothesis #1) but not calorie intake, testosterone levels, and hippocampus activity (Hypotheses #2, 3, & 4).

4.2 Relation of Results to Past Research

The ability of our correlational study to predict systolic blood pressure based on social isolation level is in line with previous research. Shankar et al. (2011) found that social isolation levels reported by participants was associated with higher systolic blood pressure. While Shankar et al. (2011), had middle-aged participants retrospectively asses their social isolation level and systolic blood pressure levels, we longitudinally assessed these variables in college students. The similarity of both out conclusions despite using different research designs suggests a generalized relationship exists between increased systolic blood pressure and increase social isolation levels.

Our correlation study failed to confirm the relationship between food intake and feeling of social isolation. Carter et al. (2007) found that following 2 and 4 weeks of social isolation, the consumption of sucrose intake in the isolated group decreased significantly than its respective baseline. The paired group of prairies did not differ from its respective baseline intake across time. In contrast to these results from previous study, our participants did not find a correlation between food intake and social isolation. The methodology of our correlation study differs from that of Carter et al. (2007) in three major ways. First, the food was consumed in two different forms. Our correlational study method relies on self-reported calorie intake per day that includes both liquid and sloid form of food whereas the Carter et al. (2007) study involves measurement of liquid sucrose intake in prairies. Such difference in the form of food intake might be one of the reasons of different results obtained. Future studies should test whether the form of food (liquid or solid) in which it is consumed predict same social isolation. Second, there was no baseline set up in our correlational study while Carter et. al (2007) constructed the baseline for intake of sucrose and water. Future studies should analyze whether no baseline for food intake predicts the social isolation. Third, our study was conducted on humans while Carter et. al (2007) study was conducted on prairie (the species that displays social behavior very much similar to humans), this might be another cause of difference in results. Future studies should test whether conducting exactly same study on humans and prairie predicts the same social isolation.

Our correlational study was not successful in proving any relationship between testosterone levels and social isolation. Hayashi et al (2020) study found an inverse association between social isolation and testosterone levels in early adolescent boys. The participants involved in Hayashi’s study collected their salivary samples at their home early in the morning, then these samples were stored in household freezers, and delivered frozen to the laboratory so that the testosterone levels could be measured. Due to a lack of resources, our methodology differed from Hayashi's study in two different ways; First, we had to measure the leg's hair growth of each participant every day during two weeks using a ruler, instead of collecting salivary samples. Second, our group was composed of three female participants and one male participant, and the study conducted by Hayashi et al (2020) was only among adolescent boys. In conclusion, our results were not significant due to a lack of laboratorial assistance to accurately measure the testosterone levels of our participants.

Our correlational study failed to confirm the relationship between spatial memory and social isolation reported by previous research. Gómez-Galán & Femenía et al. (2016) found that several aspects of hippocampus activity, measured through both electrophysiology recordings as well as enantioselective liquid chromatography, which showed significant results of increase in the basal synaptic transmission and plasticity levels by looking into the glutamatergic transmission in the brain, as well as level of voluntary running in the lab rats. The study of Gómez-Galán & Femenía et al. (2016) were able to purely isolate the independent variable, and look directly into the hippocampus when the dissection was performed on the brain— in contrast our participants did not always find that social isolation was high some days, as the study was done on humans who are still functioning in society where human interaction was more common, therefore not allowing pure isolation. The methodology of our correlational study differed from that of the Gómez-Galán & Femenía et al. (2016) study in two major ways that might account for the inconsistent results. First, differences between the studies in how they measured social isolation could have affected their findings. Our correlational study relied only upon self-reports of social isolation. Future studies should test whether the objectively verified aspects of social isolation outlined by Gómez-Galán & Femenía et al. (2016), but not subjective self-assessments, predict the spatial memory. Secondly, differences between the studies in how they measured hippocampal activity could have affected their findings. While we measured hippocampal activity on a Corsi Block Test daily average (%), Gómez-Galán & Femenía et al. (2016) used electrophysiology by measuring slices of the actual hippocampi from the lab rats and processing them with a Prism 5 software program, and inputting this data to find a P value— allowing for more accurate results. Future studies should examine whether hippocampal activity is able to predict the severity of only certain self-reported symptoms of social isolation.

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Table 1

Correlation coefficient (r) values, with number of daily trials (n) per correlation in brackets.

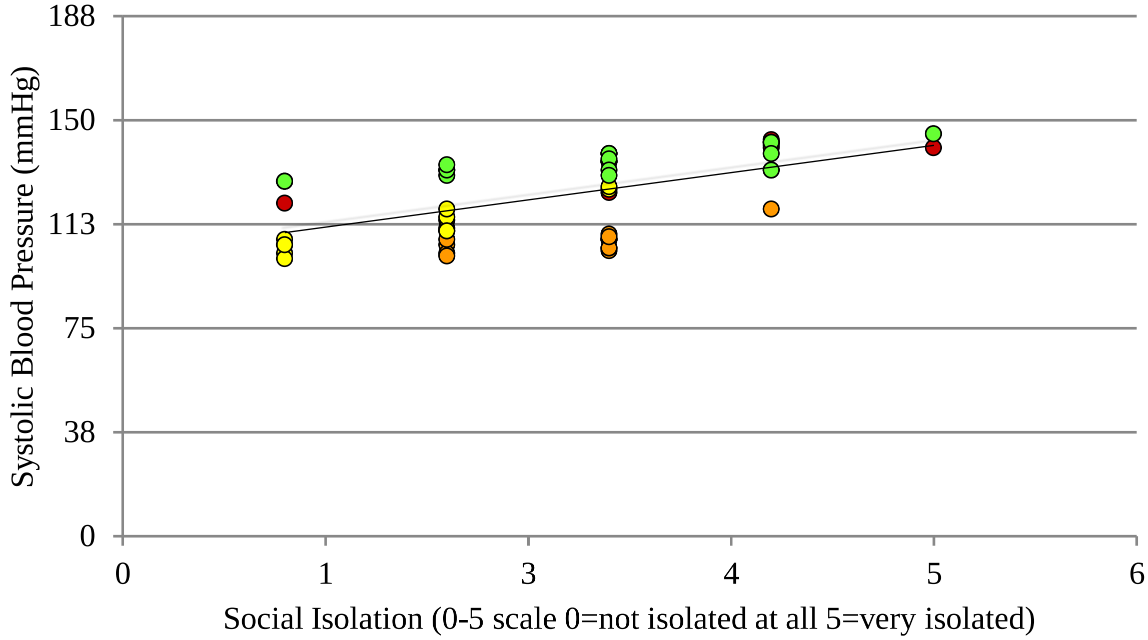
Variables correlated	Participant #1	Participant #2	Participant #3	Participant #4	Pooled raw data	Pooled standardized data
Systolic Blood Pressure & Social isolation level	.83(14)*	.45(14)	.75(14)*	0.81(14)*	.59(56)*	.71(56)*
Calorie Intake & Social isolation level	.37(14)	.33(14)	-.22(14)	.15(14)	-.06(56)	.16(56)
Testosterone level & Social isolation level	-.12(14)	.13(14)	.48(14)	-.15(14)	.01(56)	.08(56)
Spatial Memory & Social isolation level	-.08(14)	-.17(14)	-.09(14)	.10(14)	-.03(56)	-.06(56)

* $p < .05$.

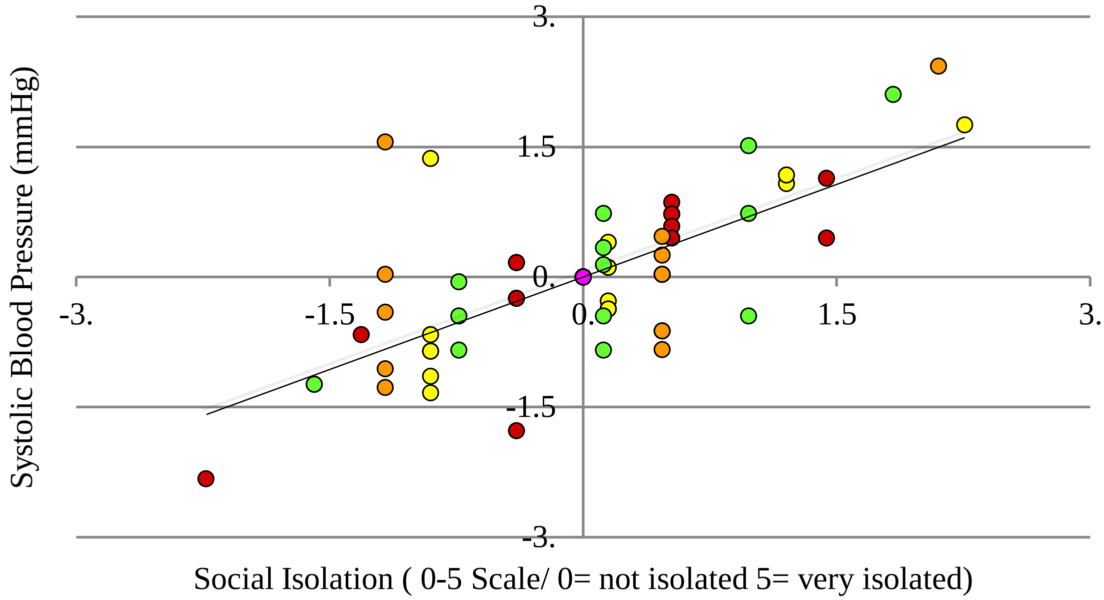
Figure 1

Scatterplot of systolic blood pressure level and social isolation level (A) raw and (B) standardized data across participants.

A.



B.

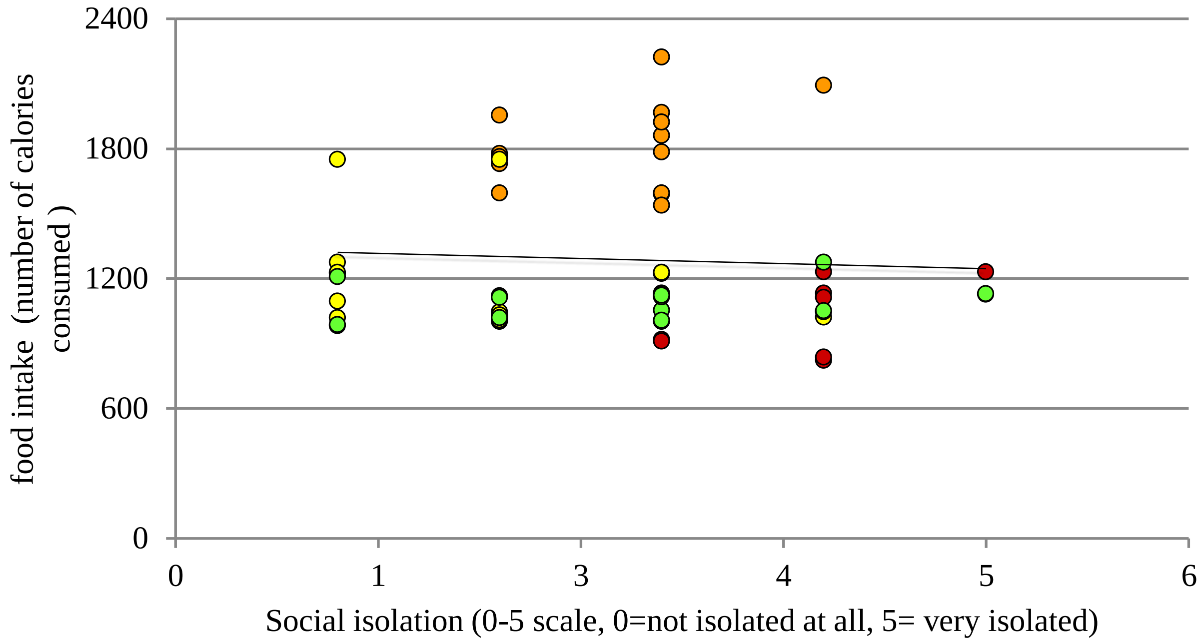


Marker colour indicates which participant data is from: red = participant #1, orange = participant #2, yellow = participant #3, and light green = participant #4. Some data might not be visible in the figure due to overlapping markers.

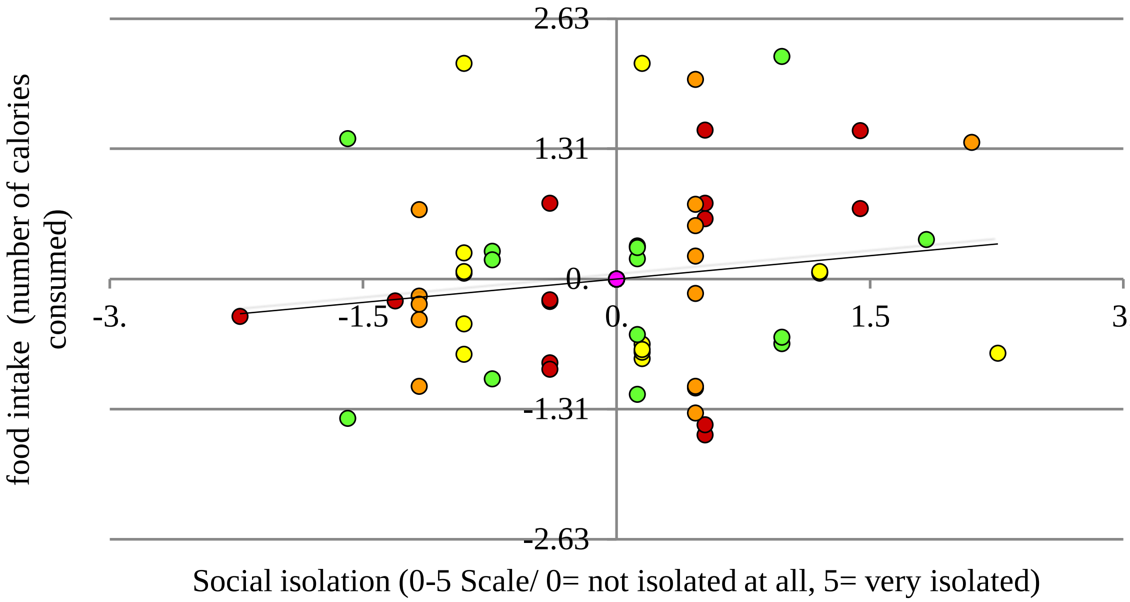
Figure 2

Scatterplot of calorie intake level and social isolation level using pooled (A) raw and (B) standardized data across participants.

A.



B.



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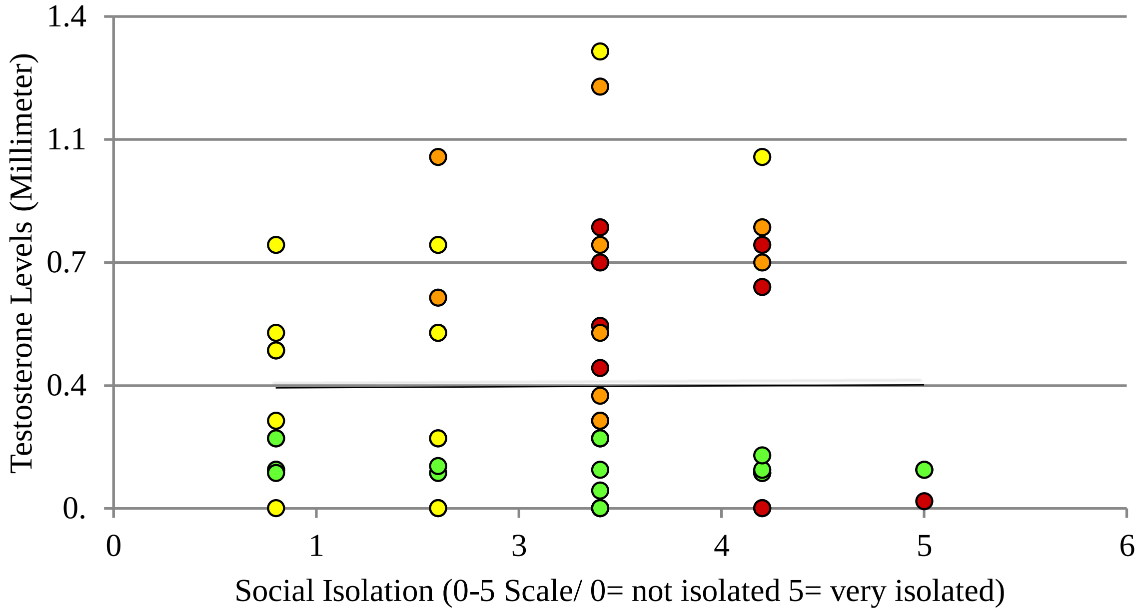
Marker colour indicates which participant data is from: red = participant #1, orange = participant #2, yellow = participant #3, and light green = participant #4. Some data might not be visible in the figure due to overlapping markers.

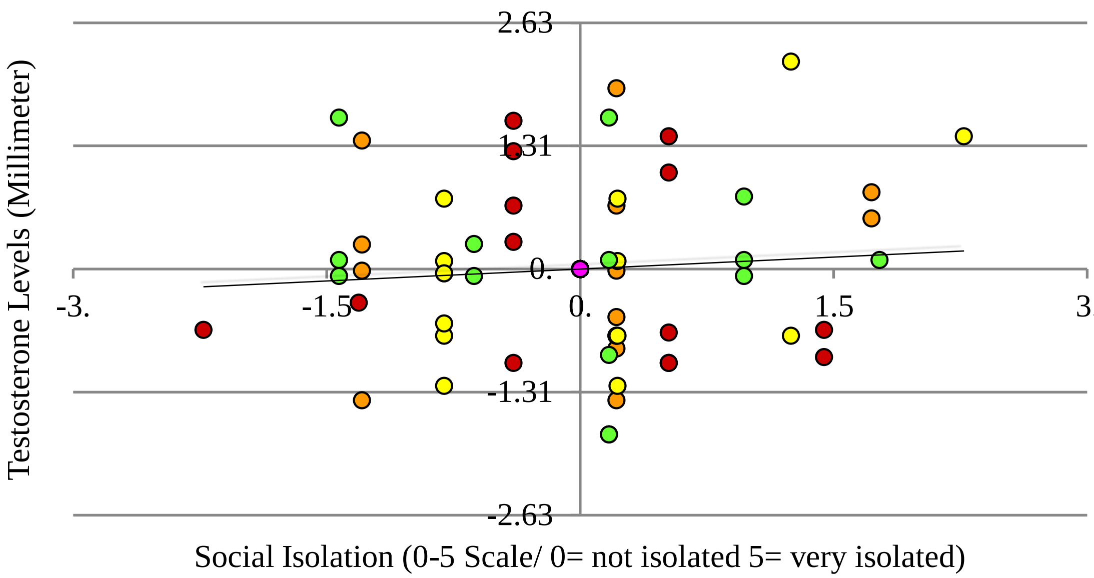
Figure 3

Scatterplot of testosterone levels and social isolation level using pooled (A) raw and (B) standardized data across participants.

A.



B.

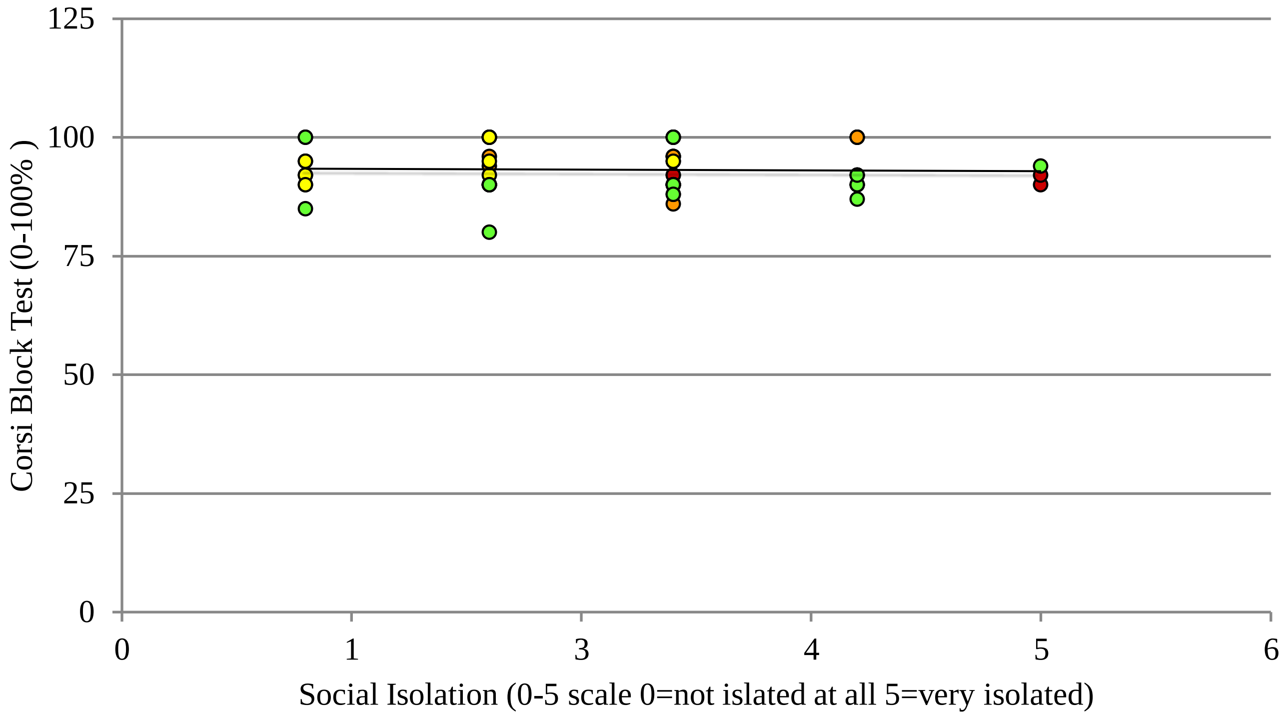


Marker colour indicates which participant data is from: red = participant #1, orange = participant #2, yellow = participant #3, and light green = participant #4. Some data might not be visible in the figure due to overlapping markers.

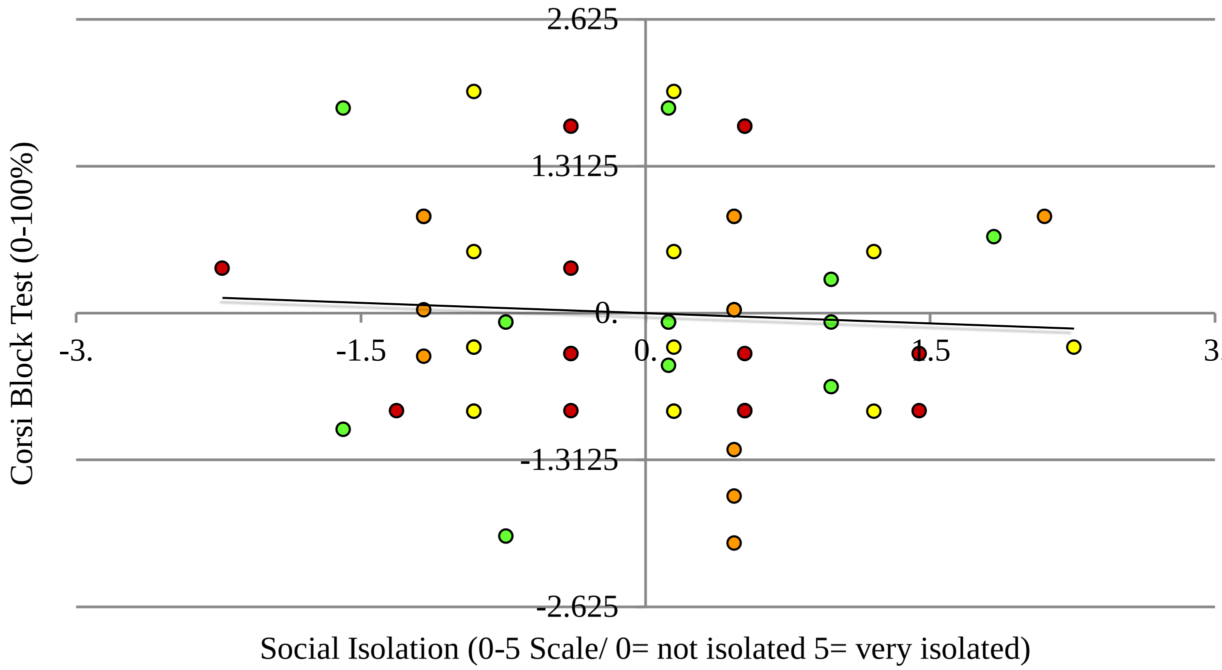
Figure 4

Scatterplot of spatial memory and social isolation level using pooled (A) raw and (B) standardized data across participants.

A.



B.



Marker colour indicates which participant data is from: red = participant #1, orange = participant #2, yellow = participant #3, and light green = participant #4. Some data might not be visible in the figure due to overlapping markers.