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Association between pet ownership and physical activity and mental health during the COVID-19 "circuit breaker" in Singapore

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ABSTRACT

Introduction: The negative impact of the coronavirus disease 2019 (COVID-19) pandemic on mental health and physical activity is well reported. While prior studies showed a positive influence of pet ownership on physical activity and mental health, the interactions between the pandemic and pet ownership are not well studied.
Objective: To determine the association between pet ownership, physical activity levels and mental health during the COVID-19 pandemic.
Materials and methods: A cross-sectional study was conducted from May 19 to July 13, 2020 among Singapore residents aged 21 to 64 years through a previously published questionnaire. Inverse probability treatment weighting was used to develop mixed-effects models for outcome comparisons. We recorded participant data on pet ownership, duration and intensity of physical activity, and RAND 36-item Health Survey mental health domains during the COVID-19 pandemic.
Results: The questionnaire was completed by 431 pet owners and 103 non-pet owners. A greater proportion of pet owners were female, non-married, employed and owned pets in the past. Pet owners reported 31.8 (95% CI 13.6 to 50; $p = .001$) more minutes per week of mild-intensity physical activity compared to non-pet owners. No statistically significant differences were found for moderate- and vigorous-intensity physical activity. Pet owners had better emotional well-being ($\beta = 9.66$, 95% CI 4.97 to 14.4; $p < .001$), energy ($\beta = 8.29$, 95% CI 3.46 to 13.1; $p = .001$) and social functioning ($\beta = 11.2$, 95% CI 5.03 to 17.4; $p < .001$) scores than non-pet owners. However, no statistically significant difference was observed for general health scores. Pet owner physical activity levels, general health, emotional well-being and energy scores correlated positively with pet attachment scores.
Conclusion: Pet ownership was associated with greater physical activity levels and better mental health, particularly in main caregivers with higher pet attachment scores. These findings suggest that pet ownership is beneficial to physical and mental well-being during periods of social isolation amidst a global pandemic.

1. Introduction

The coronavirus disease 2019 (COVID-19) outbreak was first identified in Wuhan, China in December 2019 and subsequently declared a pandemic by the World Health Organization (WHO) on March 11, 2020.

By April 19, 2020, the pandemic forced one-third to half of the global population under complete lockdown, following quarantine and social distancing recommendations set by WHO and national health ministries [1]. This provoked great concern over the psychological impact on the general population [2]. Disruption of daily routines [3], grief and loss [4], stigmatization [5], concern over economic recovery and loss of job security [6] all contribute to psychological distress, which may persist long after the outbreak is controlled [7]. A Chinese study performed early in the outbreak reported that among the general population, 53.8% experienced moderate to severe psychological impact and 16.5% reported moderate to severe depressive symptoms [8,9].

Singapore confirmed its first imported case on January 23, 2020 and first local transmission case on February 4, 2020. An increasing number

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of unlinked locally transmitted cases prompted the local government to impose public health measures to contain the outbreak from February 7, 2020 which culminated in a "Circuit Breaker" (CB) from April 7, 2020. Like a lockdown, this involved the closure of most workplaces and schools, bans of gatherings outside one's household and public movement restrictions. The CB was enforced until June 1, 2020, lasting two months before social distancing measures were gradually reversed in three progressive phases [10]. During the CB, several non-emergency psychological services were ceased [11] and an increase in calls to mental health helplines was observed [12]. This prompted the issuance of mental wellness advisories to curb the psychological impact of the pandemic and CB [13].

During the pandemic, pet and animal companionship potentially offer mental health benefits as they are able to engage and provide humans with emotional support [14]. Additionally, they motivate healthy behaviors [15] and physical activity [16] that compound the positive mental health benefits. We previously reported positive associations of pet ownership with emotional well-being and social functioning that accrue with age [17]. Such social prescription of animals for mental well-being potentially explains the increase in pet adoption [18–21] observed amidst the social isolation during the pandemic, as people seek ways to cope with the psychological stress brought on by reduced human interaction.

Existing studies concerning pets related to disease outbreaks largely focused on the risks of zoonotic transmission [22] (e.g., pets as potential zoonotic vectors of SARS-CoV-2 transmission to their owners). Fear [23], frustration and boredom [24] coupled with a volatile climate of a pandemic and quarantine led to more incidences of pet abandonment and abuse [23], despite a World Organization for Animal Health statement declaring that no evidence suggests companion animals played any significant role in the spread of COVID-19 [25]. While existing studies explored how pets affect humans confined at home [26,27], there are no studies till date examining the mental health of pet owners during the pandemic amid tightening social distancing measures. Hence, we aim to examine the impact of pet ownership on physical activity and mental health during the lockdown phase of the COVID-19 pandemic in Singapore.

2. Materials and methods

2.1. Study design

In this cross-sectional study, we recruited Singapore residents aged 21 to 64 years via social media posts and advertisements, broadcast messages, and word-of-mouth from May 19 to July 13, 2020. The study period comprised the last 2 weeks of CB (May 19 to June 1, 2020), Phase 1 (June 1 to 18, 2020; 2.5 weeks) and the first 3 weeks of Phase 2 (June 19 to July 13, 2020). These phases correspond to the gradual relaxation of social distancing measures. We excluded individuals who were not independent in their activities of daily living (ADLs) or owned therapy or guide dogs. Only one member from each household was allowed to participate.

We gave each participant a participant information sheet and obtained informed consent before participants self-administered the online questionnaire in either English, Chinese, Malay or Tamil. Data was anonymously collected via REDCap® and stored on an institutional server.

The study protocol was approved by the NUS Saw Swee Hock School of Public Health Departmental Ethics Review Committee (DERC Reference Number SSHSPH-011) with written informed consent waived. This study is reported following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Reporting Guidelines.

2.2. Definitions

We defined a pet owner as an individual who shares the same residence as a dog, cat, small mammal (rabbit, guinea pig, hamster, gerbil, mouse, chinchilla) or bird, with the exception of stray animals. We considered all other participants non-pet owners.

2.3. Survey instruments

The full questionnaire used was previously published [17]. We collected participant data on sociodemographic profile, past medical history, pet ownership and attachment levels, physical activity levels and self-perceived general and mental health. Pet owners indicated if they were the main pet caregivers.

Pet owners reported their level of involvement with pet care across four domains (feeding, healthcare, activities, hygiene) [28,29] on a 5-point Likert scale (1 "Never" to 5 "All the time"). A pet attachment score was estimated from responses to the Pet Attachment Questionnaire and the Pet Attachment Survey of the Center for the Study of Human–Animal Relationships and Environments [30], with each question scored on a 5-point Likert scale (1 "Strongly disagree" to 5 "Strongly agree").

Participants reported the duration of physical activity levels according to intensity [31]. Intensity levels were defined as follows: mild-intensity allowed for extended fluent conversation during activity, moderate-intensity allowed for conversation in short phrases during activity, and vigorous-intensity prevented any conversation during activity. Participants rated their self-perceived health-related quality of life using 4 domains of the RAND 36-item Health Survey (SF-36, version 1.0) [32]—general health, emotional well-being, energy and social functioning. A higher score reflected better self-perceived health.

2.4. Statistical analysis

Manual checking and statistical tests for extreme outliers (i.e., Cook's distance) were performed to exclude likely-erroneous records (e.g., participants who reported >1000 min of moderate physical activity per week) from analyses. Missing data was minimal, hence, analyses was performed without imputation.

We applied inverse probability treatment weighting (IPTW) to our comparative analyses to minimise confounding and selection biases. We estimated propensity scores using logistic regression modelling of baseline demographics and other relevant covariates which could predict pet ownership. Several models were developed and compared based on discrimination, calibration and Akaike information criterion [33,34]. The model exhibited good discrimination (area under receiver operating characteristics curve = 0.7608, bootstrapped bias-corrected 95% CI: 0.7090 to 08126) and calibration (p = .8920 from Hosmer-Lemeshow test with ten deciles) (Supplementary Figs. S1 and S2). Covariate distributions between pet owners and non-pet owners were balanced after IPTW (Table 1).

Comparisons of the baseline demographics and characteristics between pet owners and non-pet owners were performed using Mann-Whitney U test, Pearson's χ^2 test, and Poisson regression as appropriate for the raw dataset, and similarly using linear, logistic, and Poisson regression as appropriate for the weighted dataset.

Comparisons of physical activity levels and SF-36 outcomes between pet owners and non-pet owners were performed. As the matched design induced clustering of standard errors and correlation of responses within matched pairs, we used maximum likelihood mixed-effects linear models to estimate the average treatment effect of pet ownership for continuous outcomes. We performed subgroup analyses by incorporating a full factorial interaction between pet ownership and categorical moderator variables (i.e., the subgroup of interest) into the mixed-effects models, and calculating post-estimation subgroup-specific marginal effects.

We performed statistical analyses in Stata version 16.0 (StataCorp) and considered two-sided nominal $p < .05$ to indicate statistical significance.

Table 1
Study population baseline demographics and characteristics.

	All individuals ($n = 534$)		Raw	IPTW
	Pet owners ($n = 431$)	Non-pet owners ($n = 103$)	p-value†	p-value‡
Age, y[a]	33 (27–42)	29 (24–39)	0.0004	0.9271
21–30 (%)	144 (33.4%)	56 (54.4%)	0.0011	0.5256
31–40 (%)	149 (34.6%)	22 (21.4%)		
41–50 (%)	83 (19.3%)	14 (13.6%)		
51–64 (%)	55 (12.8%)	11 (10.7%)		
Gender, female (%)	385 (89.3%)	82 (79.6%)	0.0075	0.3396
Singaporean citizen or permanent resident (%)	412/429 (96.0%)	96/103 (93.2%)	0.4333	0.5193
Race				
Chinese (%)	369 (85.6%)	91 (88.3%)	0.4705	0.2609
Malay / Indian / Others (%)	62 (14.4%)	12 (11.7%)		
Married (%)	234 (54.3%)	86 (83.5%)	<0.0001	0.5303
Housing type				
HDB flat (%)	243 (56.4%)	72 (69.9%)		
Condominium/others (%)	147 (34.1%)	21 (20.4%)	0.0229	0.3745
Landed (%)	41 (9.5%)	10 (9.7%)		
Education level, university or above / professional degree (%)	327 (75.9%)	75 (72.8%)	0.5185	0.1914
Employed (%)	357 (82.8%)	74 (71.8%)	0.0111	0.7089
Household income > $10,000/ month (%)	174 (40.4%)	31 (30.1%)	0.0541	0.1934
No. of household members[b]	3 (2–4)	4 (2–4)	0.2011	0.8460
Past pet ownership (%)	294 (68.2%)	0 (0.0%)	<0.0001	0.5436
Medical history				
Hypertension (%)	32 (7.4%)	2 (1.9%)	0.0406	0.1699
Diabetes mellitus (%)	13 (3.0%)	1 (1.0%)	0.2431	0.3734
Hyperlipidemia (%)	29 (6.7%)	12 (11.7%)	0.0919	0.4366
Depression (%)	48 (11.1%)	12 (11.7%)	0.8821	0.8410
Anxiety disorders (%)	55 (12.8%)	11 (11.7%)	0.5642	0.8602
Schizophrenia (%)	1 (0.2%)	0 (0.0%)	0.6290	NE
Atopic conditions (formally-diagnosed)				
Asthma (%)	78 (18.1%)	18 (17.5%)	0.8826	0.9920
Allergic rhinitis (%)	60 (13.9%)	22 (21.4%)	0.0600	0.2409
Eczema (%)	89 (20.7%)	20 (19.4%)	0.7804	0.3756

IPTW: Inverse probability treatment weighting; NE: not evaluable.
[a] Median (25th percentile, 75th percentile).
[b] Median (range). Poisson count models were used since the number of household members are non-negative integers that arise from a counting process.
† P values from Mann-Whitney U test, Pearson's χ^2 test, and Poisson regression as appropriate.
‡ P values from linear, (multinomial / ordinal) logistic, or Poisson regression models with inverse probability of treatment weighting. $p > .10$ indicate that baseline variables are not significantly imbalanced after conditioning on exposure propensity scores.

3. Results

3.1. Baseline demographics

This cross-sectional study cohort comprised 431 (80.7%) pet owners and 103 (19.3%) non-pet owners (Table 1). The median pet owner age (33.0 years, IQR 27–42) was greater than that of non-pet owners (29 years, IQR 24–39; $p = .0004$). Other significant imbalances in gender, marital status, housing type, employment status and past pet ownership were found between the two groups; where a larger proportion of pet owners were female, non-married, employed, and owned previous pets.

3.2. Physical activity levels

Pet owners reported 31.8 (95% CI 13.6 to 50; $p = .001$) more minutes of weekly mild-intensity physical activity compared to non-pet owners, but moderate- and vigorous-intensity physical activity levels were similar across the two groups.

In subgroup analyses (Fig. 1), mild-intensity physical activity levels were statistically higher in pet owners who were aged 30 to 64 years, female, Chinese, married, living in a 1- to 5-room flat, employed, had a monthly household income ≥$10,000 or owned dogs as compared to non-pet owners. Dog and cat owners reported higher moderate-intensity physical activity levels while unmarried pet owners reported higher vigorous-intensity physical activity levels than non-pet owners.

Main pet caregivers and pet owners within all caregiver subgroups (feeding score ≥ 3, healthcare score ≥ 3, activities score ≥ 3, hygiene score ≥ 3) also demonstrated statistically higher physical activity levels across all intensities than non-pet owners.

3.3. SF-36

Pet owners scored higher in emotional well-being ($\beta = 9.66$, 95% CI 4.97 to 14.4; $p < .001$), energy ($\beta = 8.29$, 95% CI 3.46 to 13.1; $p = .001$) and social functioning ($\beta = 11.2$, 95% CI 5.03 to 17.4; $p < .001$) than non-pet owners, but not for general health.

In subgroup analyses (Fig. 2), emotional well-being, energy and social functioning scores were statistically higher in pet owners who were non-Chinese, married, living in a 1- to 5-room flat, employed, main caregivers, within any caregiver subgroup (feeding score ≥ 3, healthcare score ≥ 3, activities score ≥ 3, hygiene score ≥ 3), dog owners or small mammal owners as compared to non-pet owners. In addition, compared to non-pet owners, main pet caregivers, dog owners or cat owners reported better general health; pet owners living in landed property reported better emotional well-being; pet owners aged 20 to 30 years or with a monthly household income ≥$10,000 reported better energy levels; and pet owners aged 30 to 50 years or who were female reported better social functioning scores.

3.4. Continuous-by-categorical interactions and effect modifiers

We incorporated a full factorial interaction between age and pet ownership to compute the average marginal effects of pet ownership on physical activity levels and SF-36 subscales over age (Fig. 3). Statistically significant differences in mild-intensity physical activity levels (interaction $p = .0421$) and emotional well-being scores (interaction $p = .0491$) were only seen in older adults above the age of 33 and 29 years respectively, while that of energy levels were only seen in individuals less than 38 years old (interaction $p = .0362$). No statistically significant interactions were found between pet ownership and age for moderate- and vigorous-intensity physical activity levels, general health and social functioning scores.

In zero-inflated negative binomial exponential models (Fig. 4), pet owner physical activity levels of all intensities significantly positively correlated with pet attachment scores (mild: $\beta = 0.938$, 95% CI 0.886 to 0.990; $p < .0001$; moderate: $\beta = 0.681$, 95% CI 0.576 to 0.787; $p <$

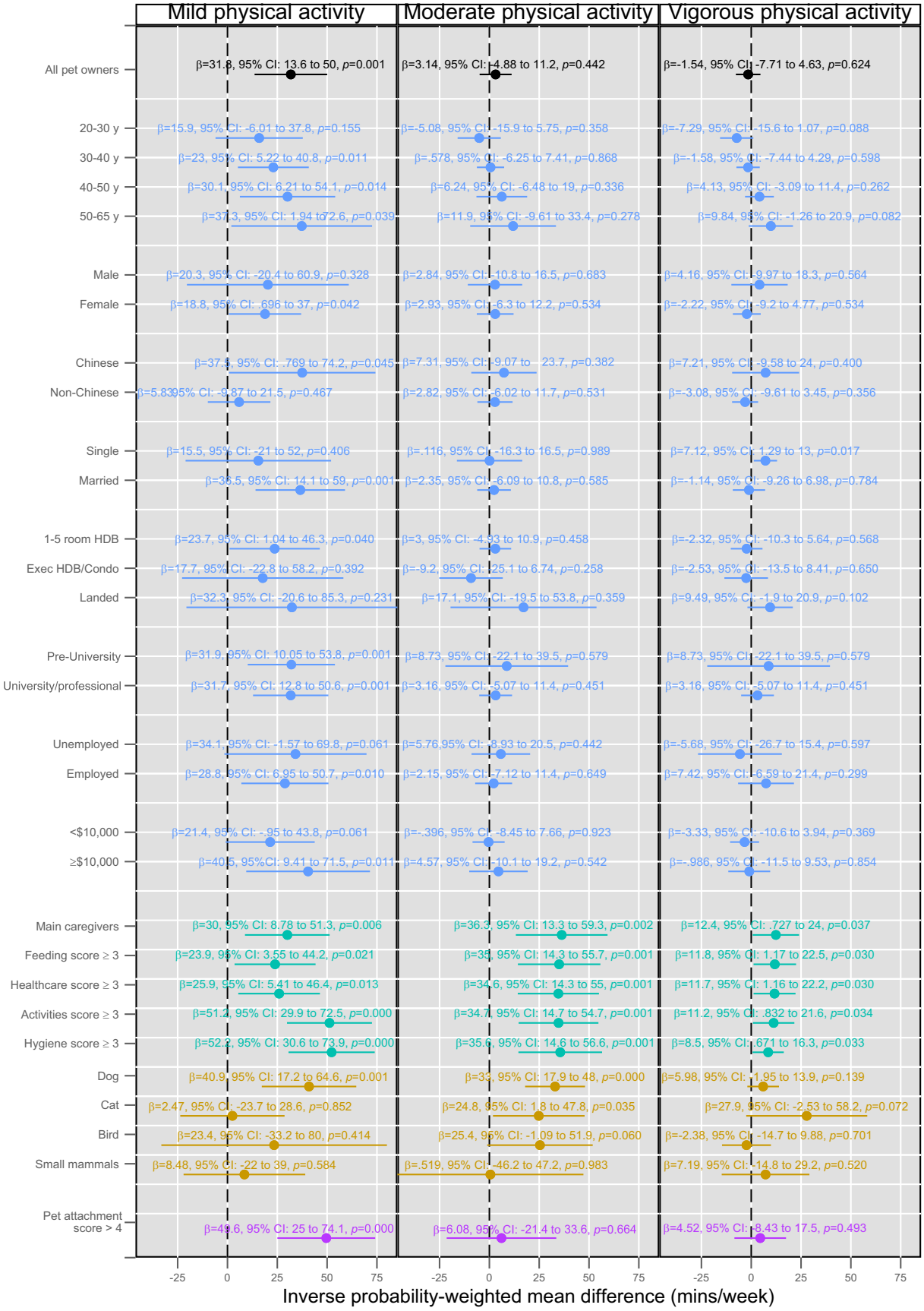

Fig. 1. Inverse probability treatment weighted-comparison of weekly physical activity levels between pet owners vs non-pet owners in the full matched set as well as selected subgroups. Subgroup-specific effects were computed as marginal contrasts by specifying a full factorial interaction between pet ownership and the relevant covariate.

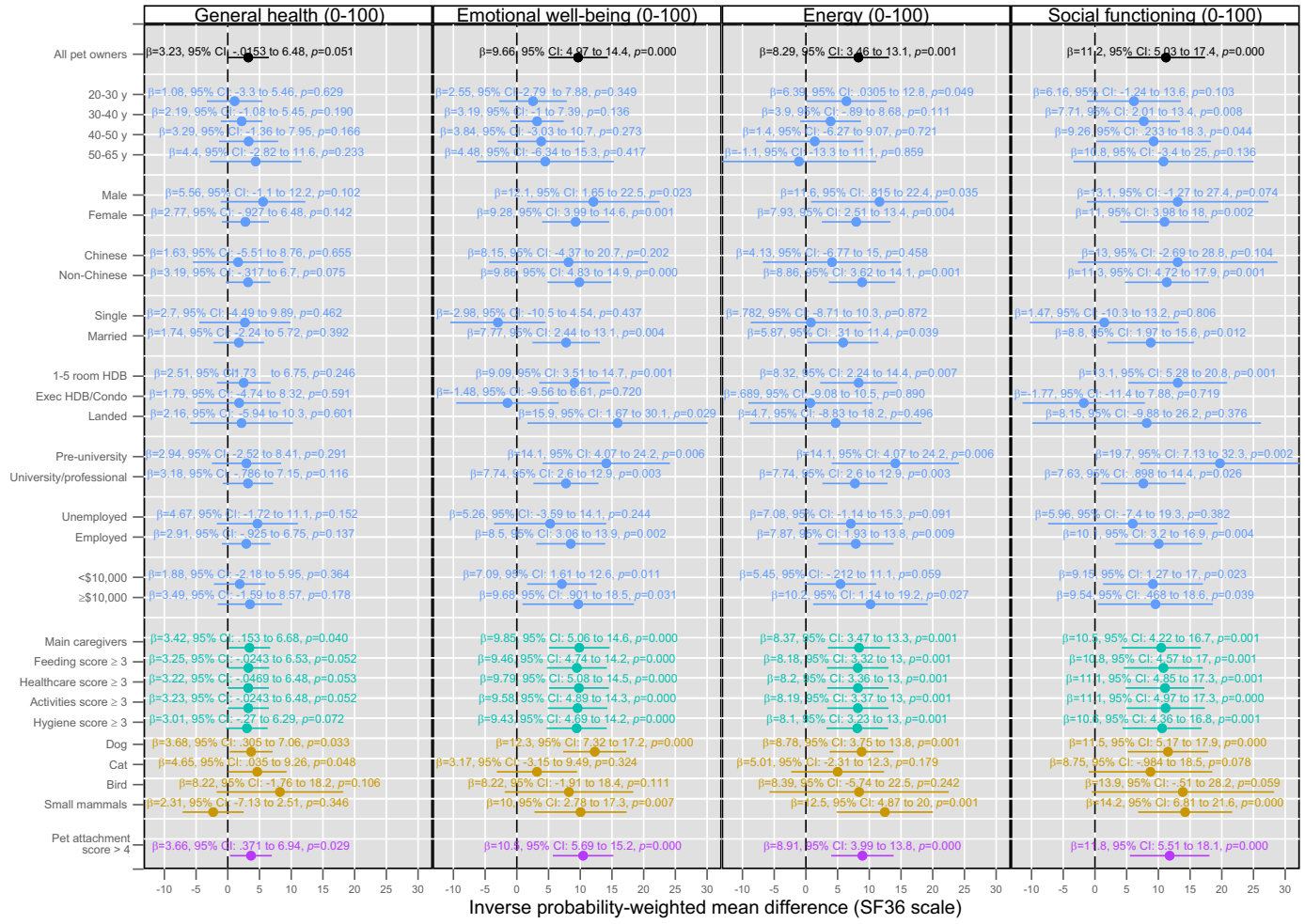

Fig. 2. Inverse probability treatment weighted-comparison of SF-36 subjective domain scores between pet owners vs non-pet owners in the full matched set as well as selected subgroups. Subgroup-specific effects were computed as marginal contrasts by specifying a full factorial interaction between pet ownership and the relevant covariate.

.0001, vigorous: $\beta = 0.630$, 95% CI 0.451 to 0.809; $p < .0001$). Using quantile regression models, pet owner general health ($\beta = 5.0$, 95% CI 1.8 to 8.1; $p = .0024$), emotional well-being ($\beta = 8.0$, 95% CI 2.3 to 13.7; $p = .0062$) and energy scores ($\beta = 6.7$, 95% CI 0.6 to 12.7; $p = .0312$) also significantly positively correlated with pet attachment scores (Fig. 4). However, no statistically significant correlation between social functioning scores and pet attachment scores were observed.

4. Discussion

In this cross-sectional study, we found that pet owners have higher mild-intensity physical activity levels, better emotional well-being, and social functioning than non-pet owners during the COVID-19 pandemic whilst undergoing quarantine and social distancing.

In our previous study before these measures were implemented, pet owners reported higher moderate- and vigorous-intensity physical activity levels than non-pet owners, likely attributable to caregiving- and pet-related activities [17]. The present study did not reproduce these findings. However, public movement at parks and recreational areas were significantly reduced by up to 70% during the study period [35] even though exercising in neighbourhood parks was a permissible reason for leaving one's home [36]. The significant reduction is likely a result of various safe management measures to reduce social interactions and disease transmission. In Singapore, before the COVID-19 pandemic, about 70% of residents visit parks at least once a year, of which almost half visit parks regularly at least once a week [37]. Furthermore, there are more than 350 parks and 4 nature reserves in Singapore, all of which are readily accessible within residential areas. An islandwide Park Connector Network with more than 300 km of trails connects major nature areas across Singapore, providing greater opportunities for physical activity and recreation. In a Draft Master Plan released by the Urban Redevelopment Authority in 2013, 90% of residents were targeted to live within 400 m of a park [38]. While other recreational areas such as sports halls, stadiums and gymnasiums were closed during CB in view of social distancing measures, parks and park connectors remained open 24 h a day for residents to enjoy. Hence, accessibility to parks was unlikely to have predominantly limited engagement in physical activities among residents.

Notably, dog owners participated in more moderate-intensity physical activity than non-pet owners, possibly because dog walking was a permissible form of exercise—allowing dog owners to maximise their opportunities to go outdoors, and thereby serving as an incentive for exercise—albeit exercise being permitted for both pet owners and non-pet owners during the CB. Furthermore, dogs encourage physical activity through the closer companionship forged [39] and their intrinsic sportiness [40]. That dog ownership promotes physical activity motivated the American Heart Association scientific statement that pet ownership, particularly dog ownership, may reasonably reduce cardiovascular disease risk [41]. In one study, dog owners walked 22 more minutes and 2760 additional steps each day on average compared to non-dog owners, mostly at a moderate cadence (≥100 steps/min) [42]. Another study showed that dog owners were 12% more physically active

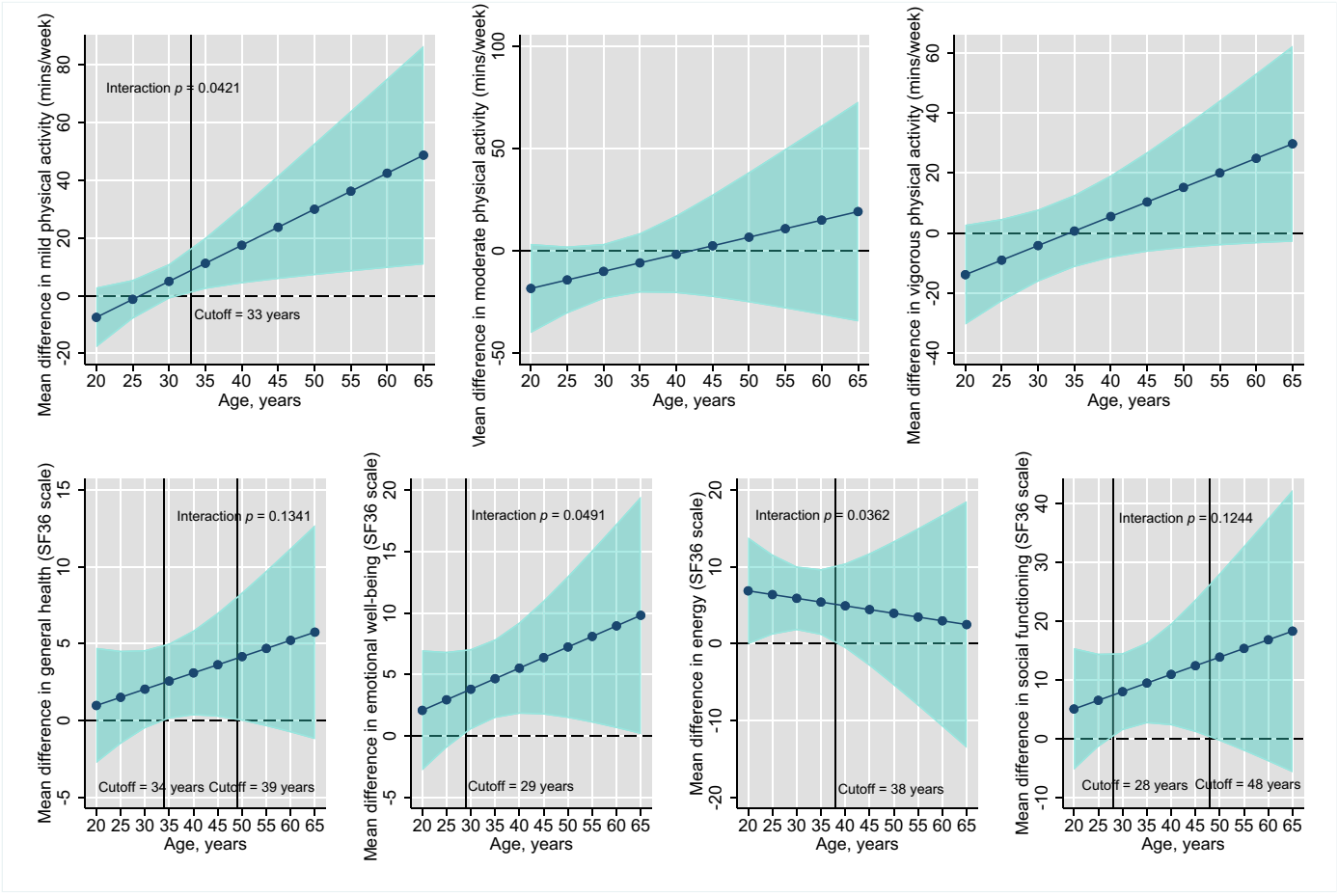

Fig. 3. Average marginal effects (95% CI) of pet ownership are plotted across age, when age is analysed as a continuous variable and a full factorial interaction between age and pet ownership is specified. *p* values for interaction terms are shown where relevant.

than non-dog owners [43].

Among pet owners, physical activity correlated with the level of pet care involvement and pet attachment, suggesting that active pet engagement, rather than mere shared residency, is crucial. These pet-pet owner interactions were further encouraged by stay-at-home and work-from-home regulations during the CB [44]. Hence, dog ownership, greater pet care involvement and closer pet attachment may serve protective roles against reduced physical activity during lockdown periods.

Pet owners scored significantly better in mental health than non-pet owners during the CB, a finding also seen in previous non-pandemic studies [45–47]. While nuanced, this relationship provides relief from damaging psychological effects [44], but is also riddled with socioeconomic stressors and uncertainty regarding disease spread [24]. Nevertheless, the balming effect of pet ownership has led to increasing local pet adoption for companionship during the pandemic [48]. This was similarly seen in the United Kingdom during the COVID-19 pandemic lockdown phase [44].

Our subgroup analyses further showed that among pet owners, those who were married, living in a 1- to 5-room flat and employed had better mental health scores than non-pet owners, among other demographic subgroups. Job loss, economic uncertainty, housing security and a lack of a holistic family unit may jeopardise the human-animal bond and increase the risk of relinquishment or abandonment during the COVID-19 pandemic [24]. Therefore, pet ownership may be limited in counteracting the negative psychological effects associated with singlehood and unemployment during a lockdown.

On the other hand, advancing age positively influenced the association between pet ownership and mild-intensity physical activity and emotional well-being, suggesting that the benefits of pet ownership may accrue with age. However, the strength of these interactions may be limited by the sample size. Such a finding, if indeed true, is useful when considering target population groups who are most likely to benefit from pet- or animal-based programmes.

Strengths of the present study included the use of IPTW to overcome confounding biases and circumvent the need to specify a functional relationship between confounders and the outcomes of interest. We also modelled the treatment-by-covariate interactions (i.e., pet ownership##covariate) which efficiently made use of observations to improve the statistical power of the analysis. We further characterised the level of pet care involvement and pet attachment of pet owners to uncover their roles in the beneficial effects of pet ownership.

However, our study is limited by a small sample size comprising mostly young respondents (median age 32 years), reducing the statistical power of our analysis and limiting the applicability of results to the older population. Many older individuals suffer from chronic medical conditions [31], are more susceptible to social isolation [49] and are more likely to develop severe COVID-19 if afflicted [50]. Hence, true interactions between age and the associations discussed may be masked by underrepresentation of these individuals. Cultural, social and economic differences may also limit the generalisability beyond the Asian population. Reduced engagement with outdoor recreational areas during this period may affect both pet owners and non-pet owners, which may have led to a higher proportion of physical activity engaged indoors, although this was not within the scope of this study. Furthermore, individual factors introduced during the pandemic such as job insecurity and financial difficulties were not evaluated. The selection bias

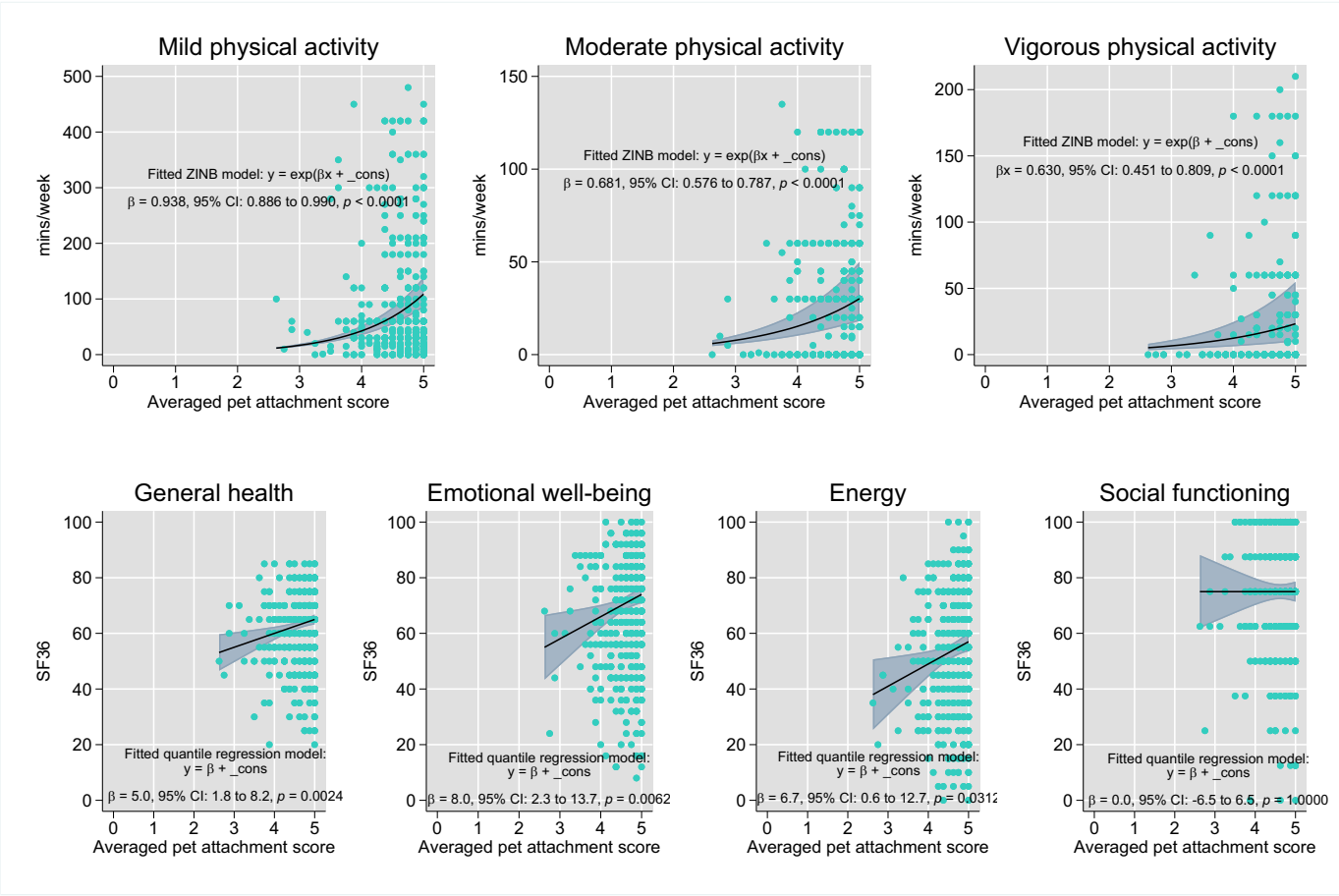

Fig. 4. Analysis of effect modification by overall pet attachment score, which was calculated as the average score of $n = 8$ questions adapted from the Pet Attachment Questionnaire by Zilcha-Mano et al. (2011). Note that only pet owners were able to provide responses to questions on pet attachment, and hence only they were included in these analyses.

introduced by convenience sampling and voluntary participation was partially attenuated by the use of IPTW, although a significant proportion of our respondents remained pet owners. As multiple testing was performed in view of the exploratory nature of the study, p values from 0.002 to 0.05 (based on the conservative Bonferroni correction procedure) should be interpreted with greater caution. We have offered explanations in the discussion to explain the plausibility of our findings.

With mental health issues rising during the COVID-19 pandemic [51], pet ownership serves as a potential alternative towards traditional psychotherapy for mental health conditions, especially when social distancing is paramount to curbing the spread of disease. Pet adoption is a viable option for those seeking companionship during periods of social isolation, although the general public should be educated on the costs and commitments associated with pet ownership. They should be warned about potential pet-mediated transmission of novel infectious diseases for which limited evidence may exist, which can induce further stress and anxiety. Owner factors like unemployment, a holistic family unit, and economic uncertainty may further blemish this potential and stall its uptake. Fostering serves as an alternative as it provides a test-trial to gauge one's ability to cope with the costs, anxieties, and work that comes with owning a pet. Lastly, whether the effects of pet ownership on mental and physical health further translate to improved outcomes of COVID-19 infected pet owners remains to be investigated.

5. Conclusion

The lockdown and social distancing experienced by many during the COVID-19 pandemic has negatively impacted both physical and mental health. Our study shows that pet ownership is associated with greater engagement in mild-intensity physical activity and better mental health during a period of lockdown, serving as a protective factor against the detrimental psychological effects of a pandemic.

Author contributions

W. Fung, B. S. W. Tan and J. Y. Low conducted the literature review. J. S. Q. Tan, N. L. Syn, Y. X. Goh, and J. Pang constructed the study design. Y. X. Goh sourced for relevant instruments and designed the questionnaire. Y. X. Goh and J. Pang coordinated the ethics approval process and supervised the study. All authors were involved in participant recruitment. J. S. Q. Tan and N. L. Syn planned and executed statistical analyses. J. S. Q. Tan, W. Fung, B. S. W. Tan, J. Y. Low, N. L. Syn and Y. X. Goh drafted and revised the main manuscript text. All authors reviewed the manuscript.

Declaration of competing interest

The authors declare no competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.onehlt.2021.100343.

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