# A systematic review, meta-analysis, and meta-regression of the impact of diurnal intermittent fasting during Ramadan on body weight in healthy subjects aged 16 years and above

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#### A systematic review, meta-analysis, and meta-regression of the impact 2

of diurnal intermittent fasting during Ramadan on body weight

in healthy subjects aged 16 years and above 4

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#### 6 Abstract

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Purpose Studies on the efect of Ramadan diurnal intermittent fasting (RDIF) on body weight have yielded conlicting 7 results. Therefore, we conducted a systematic review and meta-analysis to estimate the efect size of body weight changes in healthy, non-athletic Muslims practicing Ramadan fasting, and to assess the efect of covariates such as age, sex, fasting time duration, season, and country, using subgroup analysis, and meta-regression. Covariate adjustments were performed 10

to explain the variability of weight change in response to Ramadan fasting. 11

Methods CINAHL, Cochrane, EBSCOhost, EMBASE, Google Scholar, ProQuest Medical, PubMed/MEDLINE, Scien-12

ceDirect, Scopus, and Web of Science databases were searched from date of inception in 1950 to the end of August 2019. 13

Results Eighty-ive studies, conducted in 25 countries during 1982–2019, were identiied. RDIF yielded a signiicant, 14

but small reduction in body weight (K = 85, number of subjects, N = 4176 (aged 16–80 years), Hedges' g = -0.360, 95% 15

conidence interval (CI) – 0.405 to – 0.315,  $l^2$  = 45.6%), this effect size translates into difference in means of – 1.022 kg 16

(95% CI - 1.164 kg to - 0.880 kg). Regression analysis for moderator covariates revealed that fasting time (min/day) is a 17

significant (P < 0.05) moderator for weight change at the end of Ramadan, while age and sex are not. Variable efects for the 18 season and country were found. 19

Conclusion RDIF may confer a significant small reduction in body weight in non-athletic healthy people aged 16 years and 20

above, directly associated with fasting time and variably correlated with the season, and country. 21

Keywords Body weight · Caloric restriction · Diurnal intermittent fasting · Meta-analysis · Obesity · Ramadan · Systematic 22 review 23

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# Introduction

Obesity represents one of the causal factors for the most prevalent non-communicable diseases worldwide, with a concomitantly high economic and societal burden, respectively [1, 2]. The economic and health burden arises from the high cost of the medical management of obesity-related comorbidities, such as diabetes, cardiovascular diseases, and cancers [3]. Mounting evidence supports the notion that caloric restriction, weight-reducing diets or intermit-tent fasting, and physical exercise can reverse, or protect against, the adverse metabolic perturbations associated with obesity [4-6].

Ramadan is the ninth month of the Islamic lunar calendar, during which healthy adult Muslims refrain from consum-ing food and drink from dawn until sunset. During Rama-dan, and throughout the globe, the majority of practicing

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#### Muslims have two main meals, one immediately after sunset Database searches 42

(suhoor) and one just before dawn (iftar) [7]. During the 43

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46 fasting (RDIF) represents a unique pattern of intermittent ScienceDirect, Scopus and Web of Science from database 47 fasting that involves consistent diurnal abstinence from food inception in 1950 to the end of August 2019. The search 48 and drink, for a fasting period of 12-18 h (depending on the strategy included relevant keywords :"Islamic fasting" Or 49

season) over 29-30 days. 50 The impact of intermittent fasting and caloric restric-51 tion on body weight loss has been questioned, and several intermittent fasting" OR "Ramadan fast" OR "Intermittent 52 original research and review articles have been published prolonged fasting during Ramadan" OR "Recurrent circa-53 in an attempt to answer this guestion during the last decade dian fasting" AND "body weight" OR "body composition" 54 [5, 6, 9–16], with indings, however, bereft of uniformity. OR "body mass" OR "body mass index" OR "anthropomet-55 Given that Ramadan fasting is a form of intermittent fasting rics" OR "anthropometry". Reference lists of the obtained 56 and time-restricted feeding pattern [17, 18] that is globally studies were hand searched, and authors were contacted to 57 observed, its impact on body weight loss is of contemporary ind relevant articles and reviews and to make sure that all 58 interest. Furthermore, in a recent meta-analysis on meta-related publications were included in the current analysis. 59 bolic syndrome components (waist circumference, systolic 60 blood pressure, fasting plasma/serum glucose, triglycerides, 61 and high-density lipoprotein cholesterol) [19], bodyweight 62

change was not investigated. Thus, the present systematic 63 review and meta-analysis aimed to systematically summarize 64 and analyze available scientiic evidence and to clarify the 65 results of published literature about the efect of RDIF on 66 body weight in healthy, non-athletic people observing Ram-67 adan fasting. The current meta-analysis also investigates the 68 impact of some contextual variables, speciically; the dura-69 tion of the intermittent fasting period on the magnitude of 70 weight loss. Findings of the current review will help to sys-71 tematically and comprehensively test the efect size of body 72 weight changes in healthy, non-athletic Muslims practicing 73 fasting during Ramadan month, assess the generalizability of 74 reported results, obtain a more stable estimate of the efect 75 size of fasting during Ramadan on body weight change, and 76 conduct subgroup analyses for associated confounding fac-77 tors and to investigate diferences between diferent seasons 78 and countries. Based on the nature of Ramadan fasting that 79 involves consistent, frequent abstinence from food and drink, 80 even water, we hypothesized that this systematic review and 81 meta-analysis would show a signiicant body weight loss at 82 the end of the fasting month.

#### Materials and methods 84

This meta-analysis used Meta-analysis Of Observational 85

Studies in Epidemiology (MOOSE) as a guideline for report-86 ing indings [20]. 87

night hours, from sunset to dawn, people are permitted to Two authors (JS and MF) conducted an electronic search in 89 eat and drink freely, but they are not allowed to consume any ten databases: CINAHL, Cochrane, EBSCOhost, EMBASE, 90 food or drink after dawn [8]. Ramadan diurnal intermittent Google Scholar, ProQuest Medical, PubMed/MEDLINE, 91 92 93 94

"Ramadan fasting" OR "Ramadan diurnal fasting" OR 95 "Ramadan intermittent fasting" OR "Ramadan model of 96 97 98 99 100 101 102 103

# Inclusion criteria

We included observational and intervention clinical stud-106 ies that studied the efect of RDIF on body weight. Inclu-107 sion criteria for study selection were: (1) publication date 108 between the inception of the database in 1950 to the end of 109 August 2019; (2) original research articles published in the 110 English language; (3) studies that reported numerical values 111 (e.g., arithmetic mean with/without standard deviation, SD) 112 for the body weight; (4) studies that assessed the efect of 113 RDIF on healthy people as the target population in prospec-114 tive observational studies or as healthy controls in case-con-115 trol, semi-experimental, and experimental or interventional 116 studies. As we were looking for studies that examined the 117 efect of RDIF on body weight, we included studies that 118 measured body mass in at least two stages: before Ramadan 119 fasting month as the baseline (e.g., few days or 1-2 weeks 120 before Ramadan month or the irst few days of Ramadan 121 month), and post fasting (at least two weeks into the fasting 122 month or after completion of the fasting month). It should 123 be noted that Islamic laws pertaining to fasting specify that 124 premenopausal women are exempt from fasting during men-125 struation days; therefore, these women are not expected to 126 complete fasting for the whole month of Ramadan. A similar 127 exemption applies to older people who may ind it hard to 128 complete the entire Ramadan month and may miss some 129 fasting days. AQ3 0

# **Exclusion criteria**

The following exclusion criteria were applied on retrieved 132 articles to eliminate factors that may incur potential 133

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methodological and guality issues: (1) studies that were 134 135 exclusively conducted on fasting children and adolescents (less than 18 years old), (2) studies that included patients 136 with diferent diseases or conditions who were observing 137 RDIF including diabetes: (3) studies on the efect of RDIF 138 139 on Muslim athletes who were observing Ramadan fasting; (4) lack of full text after contacting the respective authors; 140 (5) studies that expressed changes in body weight using bar 141 graphs and curves, without reporting exact numerical val-142 ues; (6) studies on pregnant and/or lactating women who 143 were observing Ramadan fasting; (7) studies that reported 144 the post-Ramadan measurement after passing one month 145 or longer, as mounting evidence supports that biochemical 146 variables induced by RDIF disappear or return to the pre-147 fasting level after one month of Ramadan cessation [21-23]; 148 (8) case reports, abstracts, review articles, editorials, and 149 non-English-language articles; (9) unpublished, non-peer-150 151 reviewed data; all of which were excluded from the quantitative and qualitative analysis: and (10) studies that involved 152 153 special dietary and physical activity plans during the fasting month. Articles were excluded from the current analysis 154 if they met any of the aforementioned criteria. The low 155 dia-gram of study selection is presented in Fig. 1. 156

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### Main outcomes and measures

The principal outcome of this review was to report the efect of 158 RDIF as efect size changes in body weight. Two authors (JS and 159 MF) independently screened the titles and abstracts of identiied 160 studies and assessed the studies for eligibility. The screening 161 was done by irst going through all titles and abstracts to exclude 162 irrelevant publications. Two authors (JS and MF) performed the 163 initial data extraction. Any conlicts in opinion regarding study 164 eligibility were resolved through dialog with a third member (HJ) 165 to reach consensus. To standardize data extraction, the review 166 team collected data for study characteristics (e.g., title, country, 167 year, sample size, participants' characteristics such as sex, age, 168 or propor-tion of males); and the main indings for body weight 169 before 170



Fig. 1 Flowchart for the selection of publications included in the systematic review and meta-analysis

- 171 and at the end of Ramadan. Extracted data were entered into
- 172 Microsoft Excel Sheet in preparation for analyses.

# 173 Estimating fasting time length and season

174 Ramadan month, as presented in the lunar calendar, was matched with the Gregorian calendar using a time and date 175 website (https://www.timeanddate.com/holidavs/us/ramad 176 an-begins). The daily length of fasting during Ramadan 177 month was calculated using the sunrise and sunset times 178 reported for that month for the city/country of each included 179 study (https://www.timeanddate.com/sun/@8469718). Time 180 points for Ramadan fasting are the call to prayer (Athan) for 181 Fair (abstinence or Imsak time, end of pre-fasting mealtime 182 or suhoor) and sunset or Maghrib (breakfast or Iftar meal-183 time) prayer times. The sunrise prayer time is declared by 184 Fair Athan to be about a mean of 80 min before the real 185 sunrise time, as recorded in the Islamic calendar for prayer 186 times. Therefore, the actual length of fasting time was cal-187 culated by adding 80 min to the time between the sunrise 188 and sunset time points. Details of the pre-dawn Fair and 189 sunset Maghreb prayer time points on the Islamic calendar 190 are available on the Islamic Finder website for Sharjah city, 191 United Arab Emirates (UAE) (https://www.islamicinder. 192 ora/world/united-arab-emirates/292672/sharjah-prayer-times 193 /). This showed that the length of fasting time for a speciic 194 day (time between the Fair and Maghrib prayer times) was 195 787 min (approximately 13 h), which was close to the length 196 of fasting time calculated using the solar calendar (sunrise 197 198 and sunset time points) for the month of Ramadan in Sharjah during the Islamic/Hijri year 1429 AH Georgian calendar 199 year of 2008 in Sharjah city/UAE. 200 According to the meteorological deinition, the seasons 201

begin on the irst day of the months that include the equi-202 noxes and solstices: spring runs from March 1 to May 31; 203 summer runs from June 1 to August 31; fall (autumn) runs 204 from September 1 to November 30, and winter runs from 205 December 1 to February 28. When the lunar month of Ram-206 207 adan falls in two solar months, Ramadan is classiied according to the solar month with a signiicant number of days 208 (e.g., Ramadan in 2009 started on the 22nd of August. Thus, 209 Ramadan was classiled to run in autumn not summer). Start 210 day for the month of Ramadan, with its corresponding solar 211 day was taken from the website: https://www.timeanddat 212 e.com/holidays/us/ramadan-begins. 213

# 214 Data synthesis and statistical analyses

Combined means were computed when the study included
subgroups (e.g., healthy body weight, overweight, obese)
with diferent means and SD for each subgroup. See the supplementary ile (Supp. 1) for equations needed to recreating
a mean from two or more groups [24]. P values for these

combined subgroups means were calculated. All descriptive and<br/>inferential tests were performed using STATA software (Stata,<br/>M.P., 15.0. College Station, TX: StataCorp, 2017).220221222

We performed a series of one group (pre-post) meta-223 analyses using pre- and post-means model, sample size, and P-224 values (paired groups). Hedges' g value was used for efect size 225 measurement. An efect size of ≤ 0.2 was described as a small 226 efect, an efect size around 0.5 as a medium efect, and an efect 227 size around 0.8 was as a large efect. A Hedges' gvalue of one 228 229 (1) indicates the two groups difer by one SD, a g value of two indicates they difer by two SDs, and so on. Standard deviations 230 231 are equivalent to z scores (1 SD = 1 z score). In addition to 232 Hedges' g values, forest plots were used to present the results 233 graphically and to illustrate point estimates of the efect size and 234 95% conidence interval (CI). Random-efects modeling was used 235 for all analyses. Using random-efects modeling, we, therefore. 236 assume that there is not only one true efect size, rather, a distribution of true efect sizes. We, therefore, sought to estimate 237 the mean of this distribution of true efect sizes. Sensitivity 238 analyses were performed for body weight by removing one 239 study at a time to determine if the pooled efect size was arbitrary 240 or inluenced by one single study in all of the components. 241

Tau  $(\tau^2)$  and  $r^2$  statistics were used to assess the hetero-242 geneity of the solicited studies within and between studies. 243 respectively. Comprehensive Meta-Analysis version 3 [25] was 244 used for all analyses. Leave-one-out sensitivity analyses were 245 conducted by iteratively eliminating one study at a time to conirm any single study did not drive our meta-analysis indings. 246 Moderator analysis was performed using: subgroup analysis for 247 categorical variables (country, and season), and meta-248 regression for integer or decimal variables (age, the percentage 249 of male subjects, and fasting time per day). Com-puting  $\tau^2$  and 250  $^2$  statistics were particularly vital to exam-ine heterogeneity due 251 to explainable causes, for example, the timing of data collection 252 before Ramadan month, and post fasting. Cochrane Handbook 253 for Systematic Reviews of Interventions was used to interpret  $\tau^2$ 254 and  $\frac{2}{26}$ , 27]. For the  $\frac{2}{3}$  a general guide to the interpretation of 255 256  $r^2$  is as follows: 0–40%: might not be significant; 30–60%: may 257 represent moderate heterogeneity; 50-90%: may represent 258 substantial heterogeneity; 75–100%: considerable 259 heterogeneity. For  $\tau^2$  because it represents the absolute value 260 of the real variance (heterogeneity), the statistical significance 261 was used. 262

The estimating algorithm for a random-efects metaregression model was obtained using methods of moments [28].

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The beta-coeicients and *P* values resulting from mod-eling were reported. Graphical plots are presented to aid the interpretation of the results visually. Funnel-plot based analysis was used to detect publication bias. Furthermore, the nonparametric trim and ill method was used to conirm indings [29]. Subgroup analysis for body weight change was performed to investigate diferences between countries. We

Table 1 Characteristics and indings of the included studies on the efect of Ramadan diurnal intermittent fasting on body weight

| Authors                 | Year | Country/continent | Study design  | Sample<br>size <i>n</i> (%<br>male) | Mean age/age range<br>(year) | BW before<br>Ramadan<br>(kg) | BW after<br>Ramadan<br>(kg) | Discussion   | Quality<br>assessment<br>score |
|-------------------------|------|-------------------|---|-------------------------------------|------------------------------|------------------------------|-----------------------------|--|--------------------------------|
| Fedail et al. [104]     | 1982 | Sudan/Africa      | Prospective   | 24 (83.3)                           | 30                           | 69.5                         | 67.7                        | There was a signiicant   | 4                              |
| Azizi and Rasouli [105] | 1987 | Iran/Asia         | observational <sup>a</sup><br>Prospective<br>observational <sup>a</sup> | 9 (100)                             | (21–40)<br>(23–54)           | 65.4                         | 61.6                        | fall in body weight<br>There was a signiicant<br>reduction in body<br>weight | 3                              |
| Takruri [67]            | 1989 | Jordan/Asia       | Prospective<br>observational <sup>a</sup>                               | 137 (66)                            | (19–59)                      | 67.64                        | 65.54                       | The results showed a<br>signiicant loss in<br>body weight                    | 4                              |
| El Ati et al. [106]     | 1995 | Tunisia/Africa    | Prospective<br>observational <sup>a</sup>                               | 16 (0)                              | (25–39)                      | 59.3                         | 58.9                        | No signiicant changes<br>were observed in body<br>weight                     | 3                              |
| Adlouni et al. [107]    | 1997 | Morocco/Africa    | Prospective<br>observational <sup>a</sup>                               | 32 (100)                            | (25 -50)                     | 69.61                        | 67.83                       | The results showed a<br>signiicant loss in<br>body weight                    | 3                              |
| Finch et al. [108]      | 1998 | England/Europe    | Prospective<br>observational <sup>a</sup>                               | 41 (37)                             | 35.3 ± 1.8<br>(19–63)        | 71                           | 70.7                        | There were no signii-<br>cant changes in body<br>weight over Ramadan         | 4                              |
| Maislos et al. [109]    | 1998 | Israel/Asia       | Prospective<br>observational <sup>a</sup>                               | 22 (64)                             | 24 (20–45)                   | 68                           | 67                          | No signiicant changes<br>were observed in body<br>weight                     | 4                              |
| Bilto [110]             | 1998 | Jordan/Asia       | Prospective<br>observational <sup>a</sup>                               | 74 (81)                             | (20–48)                      | 72                           | 70.8                        | The results showed a<br>signiicant loss in<br>body weight                    | 4                              |
| Kayıkçıoglu [30]        | 1998 | Turkey/Asia       | Prospective<br>observational <sup>a</sup>                               | 32 (100)                            | 22.3 ± 2.9                   | 71.6                         | 70.7                        | The results showed a<br>signiicant loss in<br>body weight                    | 3                              |
| Akanji et al. [111]     | 2000 | Kuwait/Asia       | Prospective<br>observational <sup>a</sup>                               | 49                                  | 47.6 ± 10.8                  | 81.8                         | 81.5                        | There were no signii-<br>cant changes in body<br>weight over Ramadan         | 4                              |
| Ramadan [37]            | 2002 | Kuwait/Asia       | Prospective<br>observational <sup>a</sup>                               | 16 (100)                            | NR                           | 80.16                        | 79.1                        | There were no signii-<br>cant changes in body<br>weight over Ramadan         | 2                              |
| Afrasiabi et al. [112]  | 2003 | Iran/Asia         | Prospective<br>observational <sup>a</sup>                               | 16 (100)                            | NR                           | 79.8                         | 78.6                        | There were no signii-<br>cant changes in body<br>weight over Ramadan         | 2                              |
| Kassab et al. [113]     | 2003 | Bahrain/Asia      | Prospective<br>observational <sup>a</sup>                               | 44 (0)                              | (18–45)                      | 79.25                        | 78.6                        | There were no signii-<br>cant changes in body<br>weight over Ramadan         | 3                              |
| Fakhrzadeh et al. [114] | 2003 | Iran/Asia         | Prospective<br>observational <sup>a</sup>                               | 91 (55)                             | 19.9 ± 1.8                   | 63.01                        | 62.17                       | Fasting caused a sig-<br>niicant reduction in<br>weight in men               | 4                              |

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| Table 1 | (continued) |
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| Authors                    | Year | Country/continent | Study design                              | Sample<br>size <i>n</i> (%<br>male) | Mean age/age range<br>(year) | BW before<br>Ramadan<br>(kg) | BW after<br>Ramadan<br>(kg) | Discussion  | Quality<br>assessment<br>score |
|----------------------------|------|-------------------|---|-------------------------------------|------------------------------|------------------------------|-----------------------------|---|--------------------------------|
| Yucel et al. [39]          | 2004 | Turkey/Asia       | Prospective                               | 38 (55)                             | 32.5 ± 12.5<br>(20–45)       | 68.67                        | 68.64                       | No statistically sig-<br>niicant diference was<br>found before and after<br>Ramadan             | 4                              |
| Rahman et al. [115]        | 2004 | Bangladesh/Asia   | Prospective<br>observational <sup>a</sup> | 20 (100)                            | 38.27 ± 4.07                 | 64.05                        | 62.07                       | Body weight decreased<br>signiicantly during<br>Ramadan compared<br>with before Ramadan         | 3                              |
| Kassab et al. [116]        | 2004 | Bahrain/Asia      | Prospective<br>observational <sup>a</sup> | 46 (0)                              | 22±2<br>(18–45)              | 80.8                         | 80.1                        | There were no signii-<br>cant changes in body<br>weight over Ramadan                            | 4                              |
| Aksungar et al. [117]      | 2005 | Turkey/Asia       | Prospective<br>observational <sup>a</sup> | 24 (50)                             | (21–35)                      | 72.69                        | 72.58                       | There were no signii-<br>cant changes in body<br>weight over Ramadan                            | 4                              |
| Farshidfar et al. [118]    | 2006 | Iran/Asia         | Pre-experimental                          | 21 (NR)                             | NR                           | 58.77                        | 57.94                       | Decrements in mean<br>weight of cases at the<br>end of Ramadan were<br>statistically signiicant | 2                              |
| Al-Numair [119]            | 2006 | Saudi Arabia/Asia | Prospective<br>observational <sup>a</sup> | 45 (100)                            | (30 -45)                     | 85.5                         | 83.2                        | The results showed a<br>signiicant loss in<br>body weight                                       | 3                              |
| Ziaee V et al. [120]       | 2006 | Iran/Asia         | Cohort                                    | 81 (51)                             | 22.7 ± 2.3<br>(20–35)        | 62.4                         | 61.2                        | The results showed a<br>signiicant loss in<br>body weight                                       | 4                              |
| Dewanti et al. [121]       | 2006 | Indonesia/Asia    | Prospective<br>observational <sup>a</sup> | 37 (100)                            | 39±10<br>(17–62)             | 64.5                         | 63                          | The results showed a<br>signiicant loss in<br>body weight                                       | 3                              |
| Subhan et al. [97]         | 2006 | Pakistan/Asia     | Case–control longitu-<br>dinal            | 46 (100)                            | 24.2 ± 6.4<br>(16–41)        | 70.48                        | 69.96                       | Body mass in Ramadan<br>was signiicantly lower<br>relative to pre-Ram-<br>adan                  | 3                              |
| Salehi and Neghab [122]    | 2007 | Iran/Asia         | Prospective<br>observational <sup>a</sup> | 28 (100)                            | 23.4 (20–26)                 | 84.1                         | 79.03                       | Fasting resulted in a<br>signiicant decrease<br>in the mean values of<br>body weight            | 3                              |
| Al Hourani and Atoum [123] | 2007 | Jordan/Asia       | Prospective<br>observational <sup>a</sup> | 57 (0)                              | 21.6 ± 4.14<br>(18–29)       | 57.5                         | 56.9                        | Body weight decreased<br>signiicantly during<br>Ramadan fasting                                 | 3                              |

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# Table 1 (continued)

| Authors                       | Year | Country/continent | Study design                              | Sample<br>size <i>n</i> (%<br>male) | Mean age/age range<br>(year) | BW before<br>Ramadan<br>(kg) | BW after<br>Ramadan<br>(kg) | Discussion  | Quality<br>assessment<br>score |
|-------------------------------|------|-------------------|---|-------------------------------------|------------------------------|------------------------------|-----------------------------|---|--------------------------------|
| Mansi [124]                   | 2007 | Jordan/Asia       | Cohort                                    | 70 (NR)                             | 21 ± 1.6                     | 76.64                        | 72.66                       | th<br>week of Ramadan was<br>signiicantly lower<br>than pre-Ramadan<br>values               | 2                              |
| Mansi and Amneh [124]         | 2007 | Jordan/Asia       | Prospective<br>a observational            | 42 (100)                            | 21.3 ± 1.6                   | 76.64                        | 72.66                       | Body weight was sig-<br>niicantly lower than<br>pre-Ramadan values                          | 3                              |
| Moosavi et al. [125]          | 2007 | Iran/Asia         | Cohort                                    | 117 (66)                            | 23.9<br>(26.2–29.6)          | 67.6                         | 67.1                        | There was a signiicant<br>diference between the<br>pre- and post- Rama-<br>dan mean weights | 4                              |
| Ibrahim et al. [126]          | 2008 | UAE/Asia          | Prospective<br>a                          | 14 (64)                             | (25–58)                      | 70.5                         | 69.1                        | There were no signii-<br>cant changes in body<br>weight over Ramadan                        | 4                              |
| Shariatpanahi et al.<br>[127] | 2008 | Iran/Asia         | Prospective<br>observational <sup>a</sup> | 55 (100)                            | 34.1 ± 8.9<br>(34 -61)       | 80.69                        | 78.73                       | The results showed a<br>signiicant loss in<br>body weight                                   | 3                              |
| Lamri-Senhadji et al.<br>[42] | 2009 | Algeria/Africa    | Prospective                               | 46 (48)                             | 24±3                         | 61.87                        | 61.39                       | There were no signii-<br>cant changes in body<br>weight over Ramadan                        | 4                              |
| Norouzy et al. [128]          | 2010 | Iran/Asia         | Prospective cohort                        | 240 (66)                            | 40 (18–70)                   | 71.81                        | 70.72                       | Ramadan fasting caused<br>a signiicant reduction<br>in body weight                          | 4                              |
| Pathan and Patil [129]        | 2010 | India/Asia        | Prospective<br>observational <sup>a</sup> | 39 (100)                            | (25 -35)                     | 61.9                         | 60.56                       | The results showed a<br>signiicant loss in<br>body weight                                   | 3                              |
| Abedelmalek et al. [43]       | 2011 | Tunisia/Africa    | Case-control                              | 9 (100)                             | 22.1 ± 0.2                   | 74                           | 71.5                        | The body mass was<br>signiicantly lower<br>in the fourth week of<br>Ramadan                 | 3                              |
| Assadi et al. [59]            | 2011 | Iran/Asia         | Prospective<br>observational <sup>a</sup> | 58 (100)                            | 40.7 ± 7.1                   | 78.61                        | 77.24                       | The results showed a<br>signiicant loss in<br>body weight                                   | 3                              |
| Ünalacak et al. [130]         | 2011 | Turkey/Asia       | Cross-sectional                           | 20 (100)                            | 27.4 ± 5.2                   | 77.55                        | 75.5                        | Signiicant weight<br>reduction was<br>observed in the study<br>group                        | 3                              |

| Table 1 | (continued) |
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| Authors                         | Year Country/continent | Study design                              | Sample<br>size <i>n</i> (%<br>male) | Mean age/age range<br>(year) | BW before<br>Ramadan<br>(kg) | BW after<br>Ramadan<br>(kg) | Discussion   | Quality<br>assessment<br>score |
|---------------------------------|------------------------|---|-------------------------------------|------------------------------|------------------------------|-----------------------------|--|--------------------------------|
| Faris et al.[90] a              | 2012 Jordan/Asia       | Cross-sectional                           | 50 (42)                             | 32.7 ± 9.5<br>(18–51)        | 71.82                        | 70.58                       | Body weight was sig-<br>niicantly lower during<br>Ramadan as compared<br>with before Ramadan         | 4                              |
| Faris et al. [131] b            | 2012 Jordan/Asia       | Cross-sectional                           | 50 (42)                             | 32.7 ± 9.5<br>(18–51)        | 72.5                         | 71.7                        | The results showed a<br>signiicant loss in<br>body weight  | 4                              |
| Khattak et al. [78]             | 2012 Malaysia/Asia     | Prospective<br>observational <sup>a</sup> | 20 (50)                             | NR                           | 80.88                        | 69.43                       | Weight was signiicantly<br>reduced in obese<br>individuals on day 21<br>of Ramadan                   | 2                              |
| Shehab et al. [132]             | 2012 UAE/Asia          | Prospective<br>observational <sup>a</sup> | 60 (60)                             | 43.2 ± 9.4                   | 78.58                        | 77.63                       | The results showed a<br>signiicant loss in<br>body weight  | 4                              |
| Agoumi et al. [133]             | 2013 Spain/Europe      | Cohort                                    | 55 (40)                             | (18–70)                      | 77.45                        | 76.67                       | Body weight decreased<br>due to fasting in<br>Ramadan  | 4                              |
| Develioglu et al. [45]          | 2013 Turkey/Asia       | Prospective<br>observational <sup>a</sup> | 35 (100)                            | 35.86 ± 11.07 (20–59)        | 77.17                        | 75.97                       | Body weight decreased<br>signiicantly dur-<br>ing Ramadan fasting<br>compared with before<br>fasting | 3                              |
| Haouari-Oukerro et al.<br>[134] | 2013 Tunisia/Africa    | Prospective<br>observational <sup>a</sup> | 38 (100)                            | 20.8 ± 1<br>(18–23)          | 70                           | 68.7                        | There were no signii-<br>cant changes in body<br>weight over Ramadan                                 | 3                              |
| Hosseini et al. [135]           | 2013 Iran/Asia         | Semi-experimental                         | 11 (0)                              | (20–45)                      | 71.1                         | 69.9                        | The results showed a<br>signiicant decline in<br>body weight at the end<br>of Ramadan                | 3                              |
| Norouzy et al. [36]             | 2013 Iran/Asia         | Prospective observa-<br>tional            | 240 (66)                            | 40.1 ± 0.7<br>(18–70)        | 71.81                        | 70.72                       | There was a signiicant<br>reduction in body<br>weight in almost all<br>subjects                      | 4                              |
| Rohin et al. [136]              | 2013 Malaysia/Asia     | Prospective<br>observational <sup>a</sup> | 46 (30)                             | 33.04 ± 4.57<br>(25–40)      | 66.16                        | 64.81                       | There was a signiicant<br>reduction in body<br>weight  | 4                              |
| Sayedda et al. [137]            | 2013 India/Asia        | Prospective<br>observational <sup>a</sup> | 20 (100)                            | 24.65 ± 4.38<br>(19–32)      | 71.1                         | 68.92                       | Body weight was found<br>to be signiicantly<br>decreased   | 3                              |

| Table 1 | (continued) |
|---------|-------------|
|---------|-------------|

| Authors                       | Year Country/continent        | Study design                              | Sample<br>size <i>n</i> (%<br>male) | Mean age/age range<br>(year) | BW before<br>Ramadan<br>(kg) | BW after<br>Ramadan<br>(kg) | Discussion   | Quality<br>assessment<br>score |
|-------------------------------|-------------------------------|---|-------------------------------------|------------------------------|------------------------------|-----------------------------|--|--------------------------------|
| Alzoghaibi et al. [44]        | 2014 Saudi Arabia/Asia        | Prospective<br>observational <sup>a</sup> | 8 (100)                             | 26.6 ± 4.9<br>(25–35)        | 69.1                         | 66.3                        | There were no signii-<br>cant changes in body<br>weight over Ramadan                                       | 3                              |
| Cansel et al. [138]           | 2014 Turkey/Asia              | Prospective cohort                        | 40 (60)                             | 29.3 ± 5.9<br>(19–40)        | 61.8                         | 62.3                        | There were no signii-<br>cant changes in body<br>weight over Ramadan                                       | 4                              |
| Celik et al. [139]            | 2014 Turkey/Asia              | Prospective<br>observational <sup>a</sup> | 42 (100)                            | 35 ± 8.9                     | 80.4                         | 78.8                        | Ramadan fasting in<br>healthy adult men was<br>associated with signii-<br>cant decreases in body<br>weight | 3                              |
| Feizollahzadeh et al.<br>[74] | 2014 Iran/Asia                | Prospective<br>observational <sup>a</sup> | 70 (100)                            | 47.88<br>(30–70)             | 79.77                        | 77.93                       | There was a signiicant<br>reduction in body<br>weight  | 3                              |
| Hassan and Isawumi<br>[140]   | 2014 Nigeria/Africa           | Prospective<br>observational <sup>a</sup> | 60 (60)                             | 42.3 ± 16.7                  | 65.92                        | 65.29                       | There were no signii-<br>cant changes in body<br>weight over Ramadan                                       | 4                              |
| McNeil et al. [141]           | 2014 Canada/<br>North America | Prospective<br>a<br>observational         | 20 (100)                            | (20–35)                      | 90.35                        | 88.55                       | No signiicant diference<br>in body weight was<br>noted   | 3                              |
| Salahuddin and Javed [142]    | 2014 India/Asia               | Case-control                              | 30 (NR)                             | (35–65)                      | 60.47                        | 58.52                       | There were no signii-<br>cant changes in body<br>weight over Ramadan                                       | 2                              |
| Begum et al. [143]            | 2015 Bangladesh/Asia          | Prospective                               | 60 (100)                            | (24–28)                      | 61.51                        | 58.97                       | Mean body weight sig-<br>niicantly decreased   | 3                              |
| Gnanou et al. [144]           | 2015 Malaysia/Asia            | Prospective<br>observational <sup>a</sup> | 20 (100)                            | (19–23)                      | 63.07                        | 61.55                       | Subjects experienced a<br>signiicant decrease in<br>body weight  | 3                              |
| Hosseini and Hejazi<br>[145]  | 2015 Iran/Asia                | Quasi-experimental                        | 25 (52)                             | NR                           | 69.3                         | 68.79                       | The results showed a<br>signiicant decline in<br>body weight   | 2                              |
| López-Bueno et al.<br>[146]   | 2015 Spain/Europe             | Longitudinal                              | 62 (0)                              | 33.6 ± 12.7<br>(18–61)       | 67.2                         | 66.1                        | There was a signiicant<br>reduction in total body<br>weight values   | 3                              |
| Sijavand et al. [62]          | 2015 Iran/Asia                | observational <sup>a</sup><br>Prospective | 89 (57)                             | <sup>(20–50)</sup><br>34.97  | 77.59                        | 76.62                       | body weight decreased<br>A week after Ramadan,   | 4                              |
|                               |                               |   |                                     |                              |                              |                             | compared to a week before Ramadan  |                                |

| Table 1 ( | continued) |
|-----------|------------|
|-----------|------------|

| :Journa             | 3 | Authors                     | Year | Country/continent    | Study design                              | Sample<br>size <i>n</i> (%<br>male) | Mean age/age range<br>(year) | BW before<br>Ramadan<br>(kg) | BW after<br>Ramadan<br>(kg) | Discussion   | Quality<br>assessment<br>score |
|---------------------|---|-----------------------------|------|----------------------|---|-------------------------------------|------------------------------|------------------------------|-----------------------------|--|--------------------------------|
| Larg 39             |   | Suriani et al. [147]        | 2015 | Malaysia/Asia        | Prospective<br>observational <sup>a</sup> | 84 (0)                              | 39.8 ± 10.3                  | 78.76                        | 77                          | The results showed a<br>signiicant decline in<br>body weight   | 3                              |
| 22                  | - | Talib et al. [148]          | 2015 | Qatar/Asia           | Cohort                                    | 45 (100)                            | 37 ± 7.2<br>(27–56)          | 94.67                        | 94                          | The results showed a<br>signiicant decline in<br>body weight   | 3                              |
| 216:NoArticle       |   | BaHammam et al. [149]       | 2016 | Saudi Arabia/Asia    | Prospective<br>observational <sup>a</sup> | 80 (100)                            | 26.6 ± 4.9<br>(20–35)        | 67.5                         | 66.3                        | The results showed a<br>signiicant decline in<br>body weight   | 3                              |
| U                   |   | Ganjali et al. [150]        | 2016 | Iran/Asia            | Quasi-experimental                        | 45 (58)                             | 37.6 ± 6.9<br>(25 -58)       | 81.47                        | 79.62                       | The results showed a<br>signiicant decline in<br>body weight   | 4                              |
| 26:Page             |   | Syam et al. [38]            | 2016 | Indonesia/Asia       | Longitudinal                              | 43 (16)                             | 34.19 ± 11.25                | 59.82                        | 58.95                       | By the 28th day of<br>Ramadan, it was found<br>that the body weight<br>had decreased signii-<br>cantly | 4                              |
| <b>2216</b> :C      |   | Nugraha et al. [151]        | 2017 | Germany/Europe       | Prospective<br>observational <sup>a</sup> | 25 (100)                            | 26.12 ± 0.98                 | 77.82                        | 76.04                       | Participants experienced<br>a signiicant loss in<br>body weight  | 3                              |
| odeMS               |   | AbdulKareem et al.<br>[152] | 2017 | Iraq/Asia            | Case-control                              | 12 (25)                             | 37.5 ± 10.81<br>(24–57)      | 67.2                         | 66.1                        | Healthy subjects showed<br>a signiicant decrease<br>in the body weight                                 | 4                              |
|                     |   | Alsubheen et al. [80]       | 2017 | Canada/North America | Prospective<br>observational <sup>a</sup> | 9 (100)                             | 32.2 ± 7.8                   | 82.9                         | 80.8                        | Signiicant reduction<br>in body weight was<br>observed at the end of<br>Ramadan                        | 3                              |
|                     |   | Bakki et al. [153]          | 2017 | Nigeria/Africa       | Cross-sectional                           | 75 (62.6)                           | 25±2<br>(18–30)              | 59.1                         | 56.8                        | No signiicant diference<br>in body weight was<br>noted   | 4                              |
|                     |   | Khan et al. [154]           | 2017 | Pakistan/Asia        | Prospective<br>observational <sup>a</sup> | 35 (51)                             | 21.66 ± 0.68<br>(21 -23)     | 60.49                        | 60.46                       | No signiicant diference<br>in body weight was<br>noted   | 4                              |
| Dispato             |   | Kiyani et al. [155]         | 2017 | Pakistan/Asia        | Prospective<br>observational <sup>a</sup> | 80 (62.5)                           | 20.5<br>(18–24)              | 62.7                         | 62.3                        | No signiicant diference<br>in body weight was<br>noted   | 4                              |
| h : <b>7-3-2020</b> |   | Latiri et al. [156]         | 2017 | Tunisia/Africa       | Prospective<br>observational <sup>a</sup> | 29 (100)                            | 27±1<br>(20–40)              | 81.6                         | 81.2                        | There was no statisti-<br>cally signiicant efect<br>of Ramadan fasting o<br>body weight                | 3<br>n                         |

| Table 1 ( | continued) |
|-----------|------------|
|-----------|------------|

| Authors                           | Year | Country/continent | Study design                              | Sample<br>size <i>n</i> (%<br>male) | Mean age/age range<br>(year) | BW before<br>Ramadan<br>(kg) | BW after<br>Ramadan<br>(kg) | Discussion   | Quality<br>assessment<br>score |
|-----------------------------------|------|-------------------|---|-------------------------------------|------------------------------|------------------------------|-----------------------------|--|--------------------------------|
| Malekmakan et al. [60]            | 2017 | Iran/Asia         | Semi-experimental                         | 93 (52.7)                           | 37.2 ± 7.9<br>(25–57)        | 71.6                         | 70.4                        | The results showed a<br>signiicant decline in<br>body weight   | 4                              |
| Mohammadzade et al.<br>[49]       | 2017 | Iran/Asia         | Prospective observa-<br>tional            | 30 (100)                            | 29.44 ± 7.4<br>(20–35)       | 82.73                        | 80.43                       | The results showed a signiicant decline in   | 3                              |
| Norouzy et al. [61]               | 2017 | Iran/Asia         | Prospective observa-<br>tional            | 12 (50)                             | 54.6 ± 4                     | 67.4                         | 67.5                        | body weight<br>There was no statisti-<br>cally signiicant efect<br>of Ramadan fasting on<br>body weight              | 4                              |
| Ongsara et al. [157]              | 2017 | Thailand/Asia     | Prospective observa-<br>tional            | 65 (32)                             | 20.82 ± 1.14<br>(19–24)      | 55.7                         | 55.1                        | There was no statisti-<br>cally signiicant efect<br>of Ramadan fasting on<br>body weight                             | 4                              |
| Pallayova et al. [54]             | 2017 | Qatar/Asia        | Prospective observa-<br>tional            | 18 (28)                             | 24 (21–27)                   | 64.6                         | 62.2                        | There was no statisti-<br>cally signiicant efect<br>of Ramadan fasting on<br>body weight                             | 4                              |
| Roy and Bandyopadhyay<br>[158]    | 2017 | India/Asia        | Prospective<br>observational <sup>a</sup> | 36 (100)                            | 22.73 ± 1.56<br>(20–25)      | 57.5                         | 55.53                       | A slight but statistically<br>insigniicant decrease<br>in body weight fol-<br>lowing the month of<br>Ramadan fasting | 3                              |
| Al-Barha and Aljaloud<br>[35]     | 2018 | Saudi Arabia/Asia | Quasi-experimental before/after design    | 44 (100)                            | 27.7 ± 5.8<br>(18–39)        | 70                           | 69.6                        | There was no statisti-<br>cally signiicant efect<br>of Ramadan fasting on<br>body weight                             | 3                              |
| Nachvak et al. [21]               | 2018 | Iran/Asia         | Observational                             | 152 (100)                           | 39.35 ± 10.7<br>(21–63)      | 76.33                        | 74.22                       | The results showed a<br>signiicant decline in<br>body weight   | 3                              |
| Prasetya and Sep-<br>warobol [55] | 2018 | Thailand/Asia     | Prospective<br>observational <sup>a</sup> | 27 (100)                            | 24.3 ± 3.7<br>(19–40)        | 65.33                        | 64.23                       | Results demonstrate<br>reductions in body<br>weight  | 3                              |
| Faris et al. [40]                 | 2019 | UAE/Asia          | Prospective                               | 57 (61)                             | 36.2 ± 12.5                  | 89.4                         | 88.2                        | A signiicant decrease<br>in body weight was<br>observed  | 4                              |
| Haghighi et al. [159]             | 2019 | Iran/Asia         | Semi-experimental                         | 25 (0)                              | (21–51)                      | 67.62                        | 67.29                       | There was no statisti-<br>cally signiicant efect<br>of Ramadan fasting on<br>body weight                             | 3                              |

| d) <b>Table</b> 1                         |                               |  |                            |                          |                   |   |                     |
|---|-------------------------------|--|----------------------------|--------------------------|-------------------|---|---------------------|
| Authors                                   | Year Country/continent        | Studydesign  | Mean age/age range         |                          |                   | Discussion  | Quality             |
|   |                               | Samplesize<br>%/mmale)                             | « (year)                   | BW<br>beforeF<br>dan(kg) | ama BW afterRamad | an (kg)   | assessments<br>core |
| Jarrar et al. [160]                       | 2019 UAE/Asia                 | Randomized,contr 36 (14)                           |                            | 60.5                     | 59.9              | A signiicant decrease   | 4                   |
| Rahbar et al. [161]                       | 2019 Iran/Asia                | Prospectiv 34 (100)                                | ²1.±1.86(18-47)<br>35 ± 11 | 6274.                    | 9373.             | in body weight wasobserved<br>A signiicant decrease   | б                   |
| Alam et al. [57]                          | 2019 Pakistan/Asia            | a observational<br>oper-<br>abalonguideal 78 (100) | (16–64)<br>(20–85)         | 567.                     | 763.              | A significant reduction   | т                   |
|   |                               | follow-up  |                            |                          |                   | h boy wagt wastbandingards-<br>parasative of the second manufacture of th |                     |
| Not reported by<br>bộdy weight, <i>BW</i> | study authors<br>not reported |  |                            |                          |                   |   |                     |

achieved this subgroup analysis if three or more studies were 273 available from any given country. 274

## Critical appraisal of studies (quality assessment) 275

Two reviewers (MF and HJ) independently assessed the 276 methodological quality of studies using a pre-designed 277 standardized checklist consisting of six items in terms of 278 sample size and sampling technique, standardization of data 279 collection, appropriateness of statistical analyses, quality of 280 reporting results, and generalizability. The appraisal scores 281 range between zero and six, with scores of 0-2 corresponds 282 to low quality, 3-4 medium quality, and 5-6 high quality. 283 The inal quality score was set for each study by consensus 284 after discussion [19]. (See Supp. 2). 285

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## Results

Of 2253 initially retrieved studies, eighty-ive studies on the 287 efects of RDIF on body weight met the inclusion criteria 288 and were subjected to meta-analysis; the stages of evalu-289 ation and exclusion of the identiied studies are presented 290 in Fig. 1. The eighty-ive studies included a total of 4176 291 participants. Details of study sample size, sex, study design, 292 age, and signiicant indings related to body weight are found 293 in Table 1. All included studies used a pre-post model to 294 report changes in body weight. Approximately 70.7% of 295 participants were male, and the median age was 30.0 years 296 (range of 16-80 years). The mean fasting length during 297 Ramadan for all included studies was 837 min, with a SD of 298 91; range between 667 and 1070 min per day. 9

Critical appraisal of studies or quality assessment revealed that 78 studies (91.8%) were of medium-quality, and the remaining seven studies (8.2%) were of low-quality studies (Table 1). The mean quality score was 3.4, with a SD of 0.7.

## A meta-analysis of body weight

Characteristics of the selected studies regarding the num-306 ber of studies (K), the number of subjects (N), the mean 307 age of study subjects, percent of male subjects, fasting time 308 expressed in minutes per day are summarized in Table 2. 309 Visual inspection of the precision plots indicated no bias in 310 any of the selected studies (Fig. 2). Meta-analytic pooling for 311 the body weight was performed and results were expressed 312 as K, N, Hedges' g value, 95% CI and  $l^2$ , and found to be: 313 (K = 85, N = 4176, -0.360, 95% CI - 0.405 to - 0.315,314  $l^2$  = 45.6%) (Fig. 3), this efect size translates to difference 315 in means of - 1.022 kg (95% CI - 1.164 to - 0.880 kg). The 316 results of sensitivity analyses revealed that the pooled efect 317 size was robust and was not inluenced by one single study. 318

|  |  | efectofRamadandiurnal  |                  |
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|  | and statistical values for the three moderators for the  | intermittent fasting on<br>Moderators  |                  |
| p<br>s   | $\frac{2}{c}$ N d2 $\tau$ Number Mean age (year) Overall % male Fasting time (min-ute/day)   | OverallHedges' age Sex<br>(%omale)g(95%Cl)                                   | Fasting time/day |
|  | 30.±7.i3 70. 837.±87.69787 <sup>0</sup> 648  | $\beta_{1,001,-1-0000}, qdi dh diska suppojd_{10}, \rho 0.315 \end{pmatrix}$ |                  |
| identis the number of Kilarotesherumberof N<br>2<br>Mnar and om-efects meta- | studies a<br>participant b<br><sup>percentageofordiation</sup> across studies due to heterogeneity rather than chance [162]<br>analysistle ectablyovariation among the efects observed in diferent studies (between- | studyvariance)isreferred to as tau-squared [163]                             |                  |

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### Moderator analysis for body weight

Moderator analysis was performed for body weight (Table 2). 320 Results indicated that age ( $\beta = 0.0009$ , P = 0.66) and sex ( $\beta =$ 321 322 -0.0002, P = 0.70, as %male) of the fasting people were not 323 significant moderators for changes in body weight (Figs. 4. 5), respectively. However, fasting time (min/ day) was a 324 significant moderator in explaining variation in body weight 325 326 change ( $\beta = -0.0003$ , P = 0.049) (Fig. 6), suggesting that the longer the fasting time duration during Ramadan, the more 327 substantial the reduction in body weight change at the end 328 of Ramadan. 329

Subgroup analysis was performed to investigate diferences in body weight between countries (Fig. 7). Results of this analysis revealed that nine countries (Iran, Jordan, Turkey, India, Malaysia, Pakistan, Saudi Arabia, Tunisia, and UAE) contributed three or more studies, independently, in measuring body weight change during RDIF (Table 3). The greatest reduction was observed in Malavsia (Hedges' g value, 95%CI) (- 0.519,- 0.696 to - 0.341), followed by India (- 0.486, - 0.713 to - 0.259), UAE (- 0.449, - 0.603 to - 0.294), Tunisia (- 0.424, - 0.842 to - 0.006), Iran (- 0.374, - 0.430 to - 0.264), Pakistan (- 0.347, - 0.476 to - 0.218), Turkey (- 0.325, - 0.560 to - 0.090), Jordan (- 0.291,-0.381 to - 0.200), and Saudi Arabia (- 0.148, - 0.294 to -0.002) (Fig. 7).

Subgroup analysis for the season during which the Ramadan study fell revealed that the most considerable reduction in body weight was reported in summer (- 0.376, 95%CI - 0.437 to - 0.314), followed by fall (autumn) (- 0.341, 95%CI - 0.419 to - 0.263), spring (- 0.329, 95% CI - 0.562 to - 0.095) and, inally, winter (- 0.298, 95%CI - 0.419 to - 0.177) (Fig. 8).

# Discussion

This systematic review and meta-analysis highlighted the efect of RDIF on body weight and demonstrated that 353 RDIF incurs a signiicant, but small, reduction. Further, the 354 present study shows the impact of variable moderators, 355 such as age, sex, and, for the irst time, the efect of fasting 356 time duration, season, and country on body weight 357 change at the end of the fasting month. 358

Ramadan diurnal intermittent fasting (RDIF) may be one of the most extensively studied types of religious fasting [30, 31], with a vast number of original research, system-atic reviews and meta-analyses demonstrating that RDIF is associated with variable changes in body weight [32-34], body composition [33, 35-37] and fat mass [38, 39], with an emphasis on visceral fat [40], serum lipids [34, 41, 42], immunomodulatory responses [43-47], and inlammatory and oxidative stress changes [46, 48-53]. Furthermore, some

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Fig. 2 Precision plot for studies included in the meta-analysis of body weight change induced by Ramadan fasting

work has reported that RDIF afects cardiometabolic risk factors, including insulin sensitivity [54, 55], and glucose homeostasis [56], and blood pressure [57–62] in an inconsistent manner.

Azizi [7] reported that RDIF yielded changes in body 372 weight that varied between individuals, ranging from weight 373 gain to weight loss, depending on total caloric intake dur-374 ing the fasting night hours in comparison to the pre-fasting 375 intakes [7]. However, caloric intake before and during Ram-376 377 adan month was not analyzed in the current meta-analysis, which therefore warrants further research and analysis, as it 378 represents a conceivably inluential factor on body weight 379 change at the end of the fasting month. In their systematic 380 review and meta-analysis. of data from thirty-ive stud-381 ies, including 1234 subjects, Sadeghirad and colleagues 382 [32] revealed that body weight change induced by RDIF 383 was mostly reversed after Ramadan, gradually returning to 384 pre-Ramadan status [32], indicating that body weight loss 385 caused by Ramadan fasting is transient and elicits only a 386 short-term efect. The same inding was reported by Fer-387 nando and colleagues [33] in their systematic review and 388 meta-analysis on seventy studies, which included 2947 sub-389 jects; moreover, the authors also found that overweight or 390 obese fasting people exhibited a more pronounced reduc-391 tion in body weight and body fat than healthy-weight peo-392 ple. However, the latter meta-analysis has been criticized 393 because the authors included studies on physical activity 394 during Ramadan month in their analysis [63-66], and many 395 of the collected articles were not included in the inal anal-396 ysis (e.g., the Takruri study [67]). Further, neither of the 397

aforementioned meta-analyses examined the relationship398between body weight changes and moderator confounding399factors, such as age, sex, fasting time, season, and country400of study, which may conceivably impact body weight401changes at the end of the fasting month.402

The importance of body weight is based on the fact it 403 represents a predisposing factor and associated risk of CVD 404 and type 2 diabetes, in addition to other harmful metabolic 405 abnormalities, such as nonalcoholic fatty liver disease [68]. 406 Increased body weight is usually accompanied by increased 407 central obesity and diferent metabolic disorders in non-408 athletic people, such as insulin resistance, hypertension, and 409 dyslipidemia. Therefore, dietary strategies and interventions 410 that aid in alleviating and treating obesity and lowering body 411 weight are of growing, contemporary importance. Given that 412 RDIF is associated with body weight loss [32] and the 413 alleviation of inlammatory and oxidative stress states [46], 414 RDIF could viably represent a short-term pre-ventive 415 measure against metabolic syndrome in healthy people. 416

The small reduction in body weight reported in this meta-417 analysis might help in explaining the slight decline reported 418 inlammatory and oxidative stress markers in the 419 accompanied by RDIF, as indicated in a previous meta-420 analysis [46]. It is well documented that a reduction in body 421 weight is associated with the amelioration of inlammation 422 and oxidative stress levels in overweight and obese peo-ple 423 [69, 70]. Further, the presence of metabolic syndrome, for 424 which increased body weight expressed by high BMI 425

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Study name

Statistics for each study

Hedges's g and 95% CI

**Fig. 3** Hedges' *g* value with 95%, CI revealed signiicant small (-0.360) reduction in body weight was induced by Ramadan fasting. Heteroge-neity statistics: 95% CI -0.405 to -0.315,  $l^2 = 45.6\%$ . Hedges' *g* value is considered small when value = 0.2, medium = 0.5, large = 0.8



Fig. 5 Regression analysis for changes in body weight according to the sex of fasting subjects and Hedges' g values for the 85 studies (4176 sub-jects) included in the meta-analysis. The correlation was statistically non-significant (β = - 0.0002, Pvalue = 0.71)

represents the irst indicator, was found to be associated 427

with lower plasma adiponectin levels [71]; indicating adi-428

pose tissue dysfunction and a 2-4 times increased risk of 429

430 both the development of type 2 diabetes [72] and cardiovas-

- 431 cular disease [73]. Moreover, several reports have indicated
- that RDIF is associated with variable incremental levels 432

433 in adiponectin in fasting people [50, 74-76]. Recently, it was reported that RDIF is associated with a signiicant reduction in the visceral fat surface area, as measured by magnetic resonance imaging, in 57 overweight and obese subjects, concomitant with substantial reductions in the pro-inlammatory cytokines 1L-6, and TNF- $\alpha$ , and a signiicant

increase in the anti-inflammatory cytokine IL-10 [40]. 439 The same samples revealed that RDIF was associated with 440 enhanced expression of the anti-oxidant genes nuclear fac-441 tor erythroid 2 related factor 2, superoxide dismutase 2, 442 and mitochondrial transcription factor A [72]. Furthermore, 443 Fernando and colleagues, in their systematic review and 444 meta-analysis on the efect of RDIF on body fatness, found 445 a significant reduction in fat percentage between pre-Rama-446 447 dan and post-Ramadan in people with overweight or obesity (- 1.46, 95% CI - 2.57 to - 0.35%, P = 0.010), rather than 448 in normal-weight fasting subjects [33]; implying that RDIF 449 elicits a pronounced protective efect against the develop-450 ment of metabolic syndrome in overweight/obese subjects, 451 for which increased body fatness is the core etiopathologi-452 cal condition [77]. 453

Given that Ramadan fasting represents a form of time-454 restricted feeding (TRF), as reported by Patterson and Sears 455 [18]; indings of the current review are consistent with other 456 research on human and animal intermittent energy restric-457 458 tion and TRF, for which a growing evidence base is demonstrating its beneits on glucose and lipid homeostasis in 459 the short-to-medium term, even in the absence of signiicant 460 total daily caloric restriction (reduction in 25-40% of total 461 daily caloric intake). During Ramadan, the vast majority 462 of published research has revealed a lack of signiicant 463 changes in total daily caloric intake in comparison with the 464 465 pre-fasting caloric intake [78-80]. One of the mechanisms conceivably explaining how TRF, including RDIF, may 466 improve body weight regulation is related to the extended 467 fasting duration [81]. It has been reported that extended 468

fasting duration can trigger the mobilization of free fatty 469 acids, increase the production of ketones, and increase 470 fat oxidation [82]. Besides, evidence from rodent-based 471 models suggests that reducing the daily eating duration 472 can elicit beneicial efects on body weight, body 473 composition, and metabolism [83, 84]. Furthermore, such 474 beneicial efects appear to be attainable even without a 475 reduction in daily energy intake [83, 84]. 476

Total energy expenditure (TEE) and resting metabolic477rate (RMR) play a fundamental role in determining body478weight changes [85]. In the context of RDIF, few studies479have investigated the impact of RDIF on RMR and TEE480without reporting significant changes [86, 87].481

Variable changes in body compartments have been 482 reported in fasting people during the month of Ramadan, 483 which includes body water [88], fat-free mass [36], body fat 484 mass [38, 64, 89, 90] including visceral fat [40]. These 485 variable changes in body composition associated with 486 Ramadan fasting are supposed to be afected by variable 487 factors and to be determined by cultural, seasonal, geo-488 graphical, and social [91] as well as the gut microbiome, 489 genetic, and epigenetic factors [92]. 490

The findings of the current meta-analysis are con-cordant 491 with that of Sadeghirad and colleagues [32] who reported 492 that RDIF resulted in a small signiicant weight loss (- 1.24 493 kg, 95%CI - 1.60 to - 0.88 kg), with sub-stantial reductions 494 in body weight for both men (- 1.5 kg) and women (- 0.92 495 kg), respectively. The lack of difer-ence in the significance of 496 body weight loss for both sexes is in agreement with our 497 inding that sex did not work as a 498



Fig. 6 Regression analysis for changes in body weight according to fasting minutes/day of fasting subjects and Hedges' g values for the 85 stud-ies (4176 subjects) included in the meta-analysis. The correlation was statistically significant ( $\beta = -0.0003$ , P value = 0.049)

# Regression of Fasting Time/Day on Hedges's g

| Low         Low <thlow< th=""> <thlow< th=""> <thlow< th=""></thlow<></thlow<></thlow<>  | g               | Group by                    | Study name   |                  |          | Statistics f | or each s        | tudy   |                  |                | Hedges's g and 95% Ci                            |
|--|-----------------|-----------------------------|--|------------------|----------|--------------|------------------|--------|------------------|----------------|--|
| Fig. 7 Hodges: gradues in the set of the   | c               | Country                     |  | Hedges's         | Standard | Variance     | Lower            | Upper  | 7.Value          | -Value         |  |
| Fig. 7 Hedges (gradual) is a set of the s  | A               | Igeria                      | Lamri-Senhadji et al 2009                          | -0.243           | 0.147    | 0.022        | -0.532           | 0.045  | -1.654           | 0.098          |  |
| Fig. 7 Hodges 'gradues fig. 10 is  | A               | Ugeria                      | Kaush at al 2002                                   | -0.243           | 0.147    | 0.022        | -0.632           | 0.045  | -1.664           | 0.098          |  |
| The matrix of the state of the sta  | 8               | iahrain                     | Kassab et al 2003                                  | -0.286           | 0.145    | 0.023        | -0.361           | 0.208  | -0.527           | 0.598          |  |
| Formation         The second of the seco   | 8               | lahrain<br>Ianoladesh       | Rahman et al 2004                                  | -0.177           | 0.105    | 0.011        | -0.382           | 0.028  | -1.691           | 0.091          |  |
| Fig. 7 Heighes: grybues for experimental fill of the second secon   | 6               | angladesh                   |  | -0.834           | 0.252    | 0.063        | -1.327           | -0.340 | -3.309           | 0.001          |  |
| Image: The set of the se  | c               | anada<br>Canada             | Alsobheen et al 2017<br>McNeil et al 2014          | -0.314           | 0.384    | 0.147        | -1.763           | 0.118  | -2.632           | 0.164          |  |
| Fig. 7 Hedges: granue of the second s   | C               | lanada<br>Ingland           | Finch at al 1998                                   | -0.691           | 0.341    | 0.116        | -1.259           | 0.077  | -1.734           | 0.083          |  |
| Image: Numerical states of the second state state state state states of the second state state state state states of the second state state state state states s  | Ē               | ingland                     | The clar root                                      | -0.074           | 0.153    | 0.024        | -0.375           | 0.228  | -0.485           | 0.028          |  |
| 1        | G               | ≇ermany<br>≩ermany          | Nugraha et al 2017                                 | -1.078           | 0.246    | 0.061        | -1.561           | -0.695 | -4.373           | 0.000          |  |
| Tig       Non-anti-strangent of the second sec   | lr<br>Ie        | ndia                        | Begum et al 2016<br>Pathan and Patil 2010          | -0.441           | 0.134    | 0.018        | -0.703           | -0.179 | -3.302           | 0.001          |  |
| Total       Numerican final       10       1   | Ir              | ndia                        | Roy and Bandyopadhyay 2017                         | -0.317           | 0.187    | 0.028        | -0.645           | 0.011  | -1.895           | 0.058          |  |
| Fig. 7 Hodges 'g value for the fight of t  | ir<br>Ir        | ndia                        | Salahuddin and Javed 2014<br>Sayedda et al 2013    | -1.051           | 0.180    | 0.032        | -0.581           | -0.519 | -1.200           | 0.000          |  |
| Fig. 7 Hedges' gvalues in the start of a sta   | le<br>I         | ndia                        | Deventi et al 2008                                 | -0.488           | 0.116    | 0.013        | -0.713           | -0.259 | -4.197           | 0.000          |  |
| The second of 201 with the second of   | Ir              | ndonesia                    | Syam et al 2016                                    | -0.530           | 0.160    | 0.026        | -0.844           | -0.218 | -3.305           | 0.001          |  |
| Fig. 7 Hodges' grvatues for the first of   | ir<br>ir        | ndonesia<br>tan             | Afrasiabi et al 2003                               | -0.551           | 0.118    | 0.014        | -0.782           | -0.320 | -4.671           | 0.000          |  |
| Fig. 7 Hedges 'granter at 201 is 10  | le<br>In        | an                          | Assadi et al 2011                                  | -0.029           | 0.130    | 0.017        | -0.283           | 0.225  | -0.228           | 0.821          |  |
| Total and set of the set  | ie<br>Ie        | an                          | Fakhrzadeh et al 2003                              | -0.217           | 0.105    | 0.011        | -0.423           | -0.010 | -2.060           | 0.039          |  |
| Fig. 7 Hedges' gradues for end of the set  | le<br>in        | tan<br>tan                  | Farshidfar et al 2006<br>Feizollahzadeh et al 2014 | -1.018           | 0.262    | 0.069        | -1.529           | -0.502 | -3.877           | 0.000          |  |
| Fig. 7 Hedges' gradues for the first of the  | le              | an                          | Ganjali et al 2016                                 | -0.517           | 0.156    | 0.024        | -0.823           | -0.210 | -3.305           | 0.001          |  |
| Tig       Numerical of 10 / 10 / 10 / 10 / 10 / 10 / 10 / 10   | ie<br>Ie        | an<br>an                    | Hosseini and Hejazi 2015                           | -0.382           | 0.203    | 0.041        | -0.818           | -0.023 | -2.076           | 0.038          |  |
| Fig. 7 Hedges' gradues for the state of t  | le<br>le        | tan<br>tan                  | Hosseini et al 2013<br>Malekmakan et al 2017       | -1.277           | 0.389    | 0.152        | -2.040           | -0.514 | -3.279<br>-3.299 | 0.001          |  |
| Time       Name of a bit is bit is a bit is bit is a bit is a bit is a  | le le           | an                          | Mohammadzade et al 2017                            | -0.661           | 0.197    | 0.039        | -1.038           | -0.265 | -3.309           | 0.001          |  |
| Fig. 7 Hedges' graduation 1000         | ie<br>Ie        | ian                         | Nachvak et al 2018                                 | -0.310           | 0.094    | 0.009        | -0.494           | -0.128 | -3.297           | 0.001          |  |
| Fig. 7 Hedges' gradues for the start of the  | la<br>la        | ian<br>Ian                  | Norouzy et al 2010<br>Norouzy et al 2013           | -0.214           | 0.086    | 0.004        | -0.342           | -0.087 | -3.294           | 0.001          |  |
| The set of th  | ir.             | an                          | Norouzy et al 2017                                 | 0.583            | 0.292    | 0.085        | -0.010           | 1.135  | 1.927            | 0.054          |  |
| Image of the set of 1000       Image of the set of 10000       Image of the set of 100000       Image of the set of 1000000       Image of the set of 10000000       Image of the set of 100000000000000000000000000000000000  | le<br>le        | tan                         | Rahbar et al 2019<br>Salehi and Neghab 2007        | -0.289           | 0.171    | 0.029        | -0.624           | 0.047  | -1.688           | 0.091          |  |
| Fig. 7 Hedges' Water at 1917       000       000       000       000       000       000         Fig. 7 Hedges' Water at 1917       000       000       000       000       000       000       000         Fig. 7 Hedges' Water at 1917       000       000       000       000       000       000       000       000         Water at 1917       000   | le.             | an                          | Shariatpanahi et al 2007<br>Silayandi et al 2015   | -0.463           | 0.140    | 0.020        | -0.737           | -0.188 | -3.303           | 0.001          |  |
| Note of the set of the s  | le              | an                          | Ziaee et al 2006                                   | -0.376           | 0.114    | 0.013        | -0.599           | -0.153 | -3.300           | 0.001          |  |
| No.       N  | le<br>le        | taq                         | AbdulKareem et al 2017                             | -0.347           | 0.042    | 0.002        | -0.430           | -0.264 | -8.171           | 0.000          |  |
| The second se  | le.             | aq<br>vaal                  | Maising at al 1998                                 | -0.625           | 0.297    | 0.055        | -1.208           | -0.042 | -2.103           | 0.035          |  |
| Fig. 7 Hedges' gradue at 2010       000       000       000       000       000       000       000         None       Marked at 2010       000       000       000       000       000       000       000         None       Marked at 2010       000  | la              | rael                        |  | -0.409           | 0.215    | 0.048        | -0.829           | 0.012  | -1.904           | 0.057          |  |
| 1.3 1.3 Line Theorem 1991 and 1991 a  | ىل<br>بار       | ordan                       | Al- Hourani and Atoum 2007<br>Bilto 1998           | -0.262           | 0.133    | 0.018        | -0.522           | -0.001 | -1.969           | 0.049          |  |
| Image       Marked 2007       Other of the start of the star  | Ji<br>Ji        | ordan                       | Faris et al 2012a<br>Earis et al 2012b             | -0.280           | 0.142    | 0.020        | -0.558           | -0.001 | -1.970           | 0.049          |  |
| Image: Market and Ameth 2007       0.51       0.51       0.51       0.51       0.55  | Ji<br>Ji        | ordan                       | Mansi 2007   | -0.247           | 0.120    | 0.014        | -0.483           | -0.012 | -2.061           | 0.039          |  |
| 13       Users       0.21       0.02       0.01       0.01       0.01       0.01       0.00  | ال<br>ول        | ordan<br>ordan              | Mansi and Amneh 2007<br>Takruri 1989               | -0.321           | 0.155    | 0.024        | -0.628           | -0.017 | -2.087           | 0.039          |  |
| Normality       Normality       Original Difficulty       Origi  | J               | ordan                       | Abar 1 -1 -1 2000                                  | -0.291           | 0.046    | 0.002        | -0.381           | -0.200 | -5.295           | 0.000          |  |
| Kuneti       Operative at 1211       0.02   | ĸ               | Curvait                     | Ramadan 2002                                       | -0.483           | 0.143    | 0.021        | -0.952           | 0.010  | -1.891           | 0.059          |  |
| Navyaw  | ĸ               | Cuwait<br>Asisysis          | Gnanou et al 2015                                  | -0.323           | 0.126    | 0.016        | -0.667           | -0.078 | -2.690           | 0.010          |  |
| Higher       Higher Higher   | N               | falaysia.                   | Khattak et al 2012                                 | -0.834           | 0.252    | 0.063        | -1.327           | -0.340 | -3.309           | 0.001          |  |
| Marguin       Advant ist at 1997       0.018       0.008       0.008       0.008       0.000       0.000         Name       Mixed at 2017       0.000       0.000       0.000       0.000       0.000       0.000       0.000         Name       Mixed at 2017       0.000       0.000       0.000       0.000       0.000       0.000       0.000         Name       Mixed at 2017       0.000  | N               | Aalaysia                    | Suriani et al 2016                                 | -0.381           | 0.147    | 0.024        | -0.813           | -0.093 | -2.689           | 0.010          |  |
| Normal       0478       0181   | N<br>N          | falaysia<br>forcoco         | Adlouni et al 1997                                 | -0.619           | 0.091    | 0.008        | -0.696           | -0.341 | -5.725           | 0.000          |  |
| Fig. 7 Hedges' gradue fail 2017 0.027 0.018 0.008 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000   | N               | Moro coo                    | Rathi et al 2017                                   | -0.473           | 0.182    | 0.033        | -0.831           | -0.118 | -2.596           | 0.009          |  |
| Nigerie<br>Petitiste<br>Name tal 2017       Other<br>0 400       <   | N               | ligeria                     | Hassan and Isawumi 2014                            | -0.100           | 0.118    | 0.013        | -0.310           | 0.091  | -1.248           | 0.423          |  |
| Paistan       Kian et al 2017       0.278       0.016       0.025       0.026       0.007       0.007         Paistan       Subhar et al 2017       0.278       0.016       0.025       0.056       0.007       0.000       0.000         Paistan       Subhar et al 2017       0.266       0.027       0.168       0.025       0.000       0.000       0.000       0.000         Case       Paistan       Subhar et al 2017       0.266       0.027       0.010       0.028       0.000   | N               | ligeria<br>Pakistan         | Alam et al 2019                                    | -0.122           | 0.085    | 0.007        | -0.289           | 0.045  | -1.428           | 0.153          |  |
| Titling       Nother als 2001       0.207       0.111       0.010       0.010       0.010       0.000       0.000         Milling       Submark als 2016       0.207       0.011       0.010       0.010       0.010       0.000       0.000         Other       Malling       Submark als 2016       0.000       0.000       0.000       0.000       0.000       0.000       0.000         Other       Malling       Column       Malling       Column       Malling       Column       Malling       Column       Malling       Column       Malling       Malli   | 2               | akistan                     | Khan et al 2017                                    | -0.279           | 0.109    | 0.028        | -0.610           | 0.051  | -1.057           | 0.097          |  |
| Pairing       Pairing       0.347       0.868       0.004       0.478       0.828       0.000         Data       Tails et al 2017       0.268       0.002       0.228       0.000       0.288       0.000         Data       Advances and Aplified 2016       0.001       0.117       0.018       0.227       0.028       0.000       0.118       0.288       0.010       0.000       0.011       0.000       0.011       0.000       0.011       0.000       0.011       0.000       0.011       0.000       0.011       0.000  | P               | Pakistan<br>Pakistan        | Subhan et al 2006                                  | -0.297           | 0.113    | 0.013        | -0.598           | -0.015 | -2.065           | 0.039          |  |
| Caser       Table at 2015       0.400       0.152       0.202       0.600       0.000         Save/ Arabia       Al-barns and Ajalsuc 2016       0.002       0.144       0.002       0.204       0.000         Save/ Arabia       Al-barns and Ajalsuc 2016       0.002       0.144       0.002       0.204       0.000       0.999         Save/ Arabia       Alterphaile at 2014       0.012       0.100       0.204       0.204       0.204       0.999       0.440       0.999         Save/ Arabia       Alterphaile at 2014       0.012       0.114       0.204       0.204       0.204       0.999       0.447       0.999         Save/ Arabia       Alterphaile at 2016       0.021       0.314       0.024       0.204       0.999       0.447       0.999         Save/ Arabia       Alterphaile at 2016       0.520       0.114       0.204       0.209       0.990       0.990       0.990         Sudam       Fedal et at 1016       0.202       0.114       0.206       0.331       0.901       0.990       0.990       0.990       0.990       0.990       0.990       0.990       0.990       0.990       0.990       0.990       0.990       0.990       0.990       0.990       0.9   | P               | Pakistan<br>Datar           | Pallavova et al 2017                               | -0.347           | 0.066    | 0.004        | -0.478           | -0.218 | -5.266           | 0.000          |  |
| Hase       Alcenta and Algebour 2016       0.003       0.147       0.000       0.000       0.000         Suid Arabia       Alcenta and Algebour 2016       0.002       0.202       0.200       0.000       0.000         Suid Arabia       Alcenta and Algebour 2016       0.002       0.202       0.200       0.000       0.000         Suid Arabia       Balanceman et al 2016       0.012       0.001       0.000       0.000       0.000         Suid       Arabia       Balanceman et al 2016       0.002       0.200       0.000       0.000         Suid       Arabia       Diamono et al 2016       0.002       0.000       0.000       0.000         Suid       The allows       Concortication et al 2017       0.020       0.000       0.000       0.000         Suidant       The allows       Concortication et al 2017       0.020       0.020       0.000       0.000       0.000         Suidant       The allows       Concortication et al 2017       0.020       0.020       0.000       0.000       0.000       0.000         Considered small       When values       Concortication et al 2017       0.000       0.000       0.001       0.000       0.001       0.000       0.000       0.000   | a               | Datar                       | Talib et al 2015                                   | -0.400           | 0.152    | 0.023        | -0.699           | -0.102 | -2.626           | 0.009          |  |
| Build Atabia<br>Sudd Atabia<br>Sudd Atabia<br>Sudd Atabia<br>Bakamam et al 2016       0.237<br>0.120       0.120<br>0.120       0.020<br>0.120       0.020<br>0.020       0.020<br>0.020       0.020<br>0.020       0.020<br>0.020       0.020<br>0.020       0.020<br>0.000       0.020<br>0.000       0.020       0.000       0.000       0.001       0.000       0.001       0.000       0.001       0.001       0.000       0.001       0.000       0.001       0.000       0.001       0.000       0.001       0.000       0.001       0.000       0.001       0.000       0.001       0.000       0.001       0.000   | s               | latar<br>Saudi Arabia       | AL-barha and Aljaloud 2018                         | -0.002           | 0.127    | 0.015        | -0.292           | 0.288  | -0.013           | 0.990          |  |
| Staudi Arabia<br>Susci Arabia<br>Spain       Batamman et al 2016       0.123       0.111       0.026       -0.244       0.265         Spain       López-Bueno et al 2016       0.223       0.114       0.265       0.960       0.800         Spain       Agoumi et al 2015       0.252       0.056       0.114       0.265       0.800       0.800         Spain       Agoumi et al 2015       0.056       0.118       0.021       0.803       0.233       0.800         Sudar       Fedat et al 2017       0.124       0.014       0.225       0.020       0.800         Sudar       Trailand       Organa et al 2017       0.244       0.225       0.801       0.801       0.801         Sudar Network       Organa et al 2017       0.246       0.225       0.800       0.801       0.801         Sudar Network       Organa et al 2017       0.256       0.114       0.026       -188       0.801         Considered small       When value       Quencial Calcing and the al 2017       0.026       0.826       0.831       -1.884       0.806         Turisia       Lateir et al 2017       0.056       0.826       0.827       0.827       0.827       0.827       0.827       0.827       0.827  | S               | sudi Arabia<br>Saudi Arabia | Al-Numair 2006<br>Alzophaibi et al 2014            | -0.295<br>-0.376 | 0.150    | 0.022        | -0.589           | -0.002 | -1.971           | 0.049          |  |
| Second Attals       0.148       0.014       0.001       0.024       0.002       0.000         Brain       Agoumi et al 2013       0.022       0.141       0.010       0.731       0.000       0.000         Brain       Agoumi et al 2013       0.029       0.001       0.731       0.000       0.000         Brain       0.029       0.744       0.222       0.000       0.711       0.000       0.001         Statem       Fedal et al 1012       0.744       0.222       0.000       1.114       0.000       0.001         Statem       Trailand       Organa et al 2017       0.228       0.000       0.001       0.001         Trailand       Organa et al 2017       0.228       0.000       0.001       0.001       0.001         Considered small       Memory All 2020       0.891       0.001       0.001       0.001       0.001         Tunial       Tunial       Calcular Calcula   | s               | audi Arabia                 | Bahammam et al 2016                                | -0.123           | 0.111    | 0.012        | -0.341           | 0.095  | -1.104           | 0.269          |  |
| Brain         Ageumi et al 2013         0.666         0.143         0.027         3.900         0.000           Stain  | s               | saudi Arabia<br>Spain       | López-Bueno et al 2015                             | -0.148           | 0.074    | 0.005        | -0.294           | -0.260 | -3.900           | 0.047          |  |
| Sudan<br>Twilling         Fedal et al 1992         0.744         0.229         0.000         1194         0.003         0.001           Twilling         Organ et al 2017         0.289         0.000         1194         0.000         1098         0.001           Twilling         Organ et al 2017         0.289         0.010         0.001         1098         0.001           Fig. 7 Hedges'         Organ et al 2017         0.289         0.010         1018         0.001         1018         0.001           considered small         when value         0.02         metal et al 2017         0.000         0.001         0.001         1.588         0.001           Twilling         Twilling         0.001         0.000         0.001   | 8               | ipain<br>Spain              | Agoumi et al 2013                                  | -0.659           | 0.143    | 0.021        | -0.839           | -0.278 | -3.900           | 0.000          |  |
| Fig. 7 Hedges'       Organize tal 2017<br>Thailand       0.444<br>Organize tal 2017<br>Dialand       0.444<br>Organize tal 2016<br>Dialand       0.444<br>Organize tal 2014<br>Dialand       0.444<br>Organize t   | S               | ludan                       | Fedail et al 1982                                  | -0.744           | 0.225    | 0.050        | -1.184           | -0.303 | -3.310           | 0.001          |  |
| Trailand       Pressperand Spreadout 2013       0.683       0.001  | T               | hailand                     | Ongsara et al 2017                                 | -0.235           | 0.226    | 0.050        | -0.478           | 0.009  | -1.888           | 0.001          |  |
| 13       User Fride 12014       0.051       0.052       0.055       0.052       0.050         13       User Fride 12014       0.054       0.054       0.055       0.055       0.055       0.055         14       0.055       0.055       0.055       0.055       0.055       0.055       0.055       0.055         1       0.055       0.057   |                 | hailand                     | Prasetya and Sapwarobol 2018                       | -0.693           | 0.209    | 0.044        | -1.103           | -0.282 | -3.309           | 0.001          | dide included in moto dealveis Hodgos' avalue is |
| Considered small when varue 2002, medium = 015, large 016, 1-184, 0.088<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>Tonisia<br>To | rig. / neuges ( | g values i                  |  | IT DOO           |          | Ign 1        | JI 434           | 0.00   | unine            | -Siuu          |  |
| Tunisia Latin et al 2017 0.006 0.181 0.033 0.389 0.360 0.026 0.980<br>   | considered sma  |                             |  | aiää             | = 0.5    | , larg       | €0.627           | 0.82   | -1.914           | 0.058          |  |
| Turkey         Absurger vial 2005         0.380         0.200         0.402         0.180         0.012         1.5802         0.007           Turkey         Canal et al 2014         0.170         0.158         0.024         -1.5802         0.047           Turkey         Canal et al 2014         0.570         0.128         -1.5802         0.047           Turkey         Call et al 2014         0.597         0.168         0.262         -1.337         0.011           Turkey         Call et al 2014         0.597         0.168         0.262         -0.337         0.011   | T               | 'unisia<br>'unisia          | Latini et al 2017                                  | -0.006           | 0.181    | 0.033        | -0.359           | 0.360  | -0.026           | 0.980          |  |
| 13       Unkey       Callance int 2011       0.110       0.110       0.110       0.110       0.110       0.218         14       Constrainty       Callance int 2013       0.650       0.025       0.625       0.601       0.001         Turkey       Developilue at 2013       0.655       0.160       0.025       0.685       0.001       0.001         Turkey       Developilue at 2013       0.655       0.160       0.022       0.682       0.601       0.001         Turkey       Kaylongule at 1090       0.473       0.102       0.023       0.681       0.001       0.001         Turkey       Unalscale it al 2011       0.502       0.622       0.682       0.692       0.693       0.001       0.001         Turkey       Void it al 2004       0.223       0.601       0.002       0.993       0.993       0.993       0.993         UAE       Farik et al 2019       0.245       0.101       0.400       0.903       0.993       0.993         UAE       Ibrahine tal 2006       0.217       0.017       0.977       0.907       0.993       0.993       0.993       0.993         UAE       Ibrahine tal 2006       0.2170       0.027       0.011   | T               | urkey                       | Aksungar et al 2005                                | -0.390           | 0.205    | 0.042        | -0.793           | 0.012  | -1.902           | 0.057          |  |
| Turkey         Developing et al 2013         0.666         0.180         0.024         3.307         0.001           Turkey         Kaylocolu et al 1096         -0.73         0.162         0.033         -0.81         -0.81           Turkey         Unalazak et al 2011         -0.504         0.229         0.652         -0.116         -2.568         0.003           Turkey         Unalazak et al 2011         -0.504         0.229         0.652         0.116         -0.563  | T               | untey<br>Turkey             | Celik et al 2014<br>Celik et al 2014               | -0.537           | 0.158    | 0.026        | -0.137<br>-0.855 | -0.219 | -3.306           | 0.278          |  |
| Turkey         Unalacak et al 2011         0.504         0.223         0.052         0.855         2.199         0.028           Turkey         Yucek et al 2004         0.023         0.106         0.023         0.106         0.134         0.893           Turkey         Yucek et al 2004         0.623         0.106         0.023         0.106         0.134         0.893           UAE         Farik et al 2019         0.454         0.137         0.014         0.509         2.777         0.027         P           UAE         Farik et al 2019         0.454         0.137         0.017         0.011         4.900         0.055         P           UAE         Jamme et al 2019         0.454         0.107         0.011         4.900         0.005         P           UAE         Sheabab et al 2012         0.373         0.127         0.137         0.139         0.802         P           UAE         Sheabab et al 2012         0.373         0.127         0.127         0.139         0.873         0.803         P           UAE         Other al 2019         0.454         0.006         0.000         P         P           UAE         Sheabab et al 2012         0.372         0.2   | T               | urkey<br>urkey              | Develioglu et al 2013<br>Kaykcoglu et al 1998      | -0.595           | 0.180    | 0.032        | -0.948<br>-0.831 | -0.242 | -3.307<br>-2.598 | 0.001          |  |
| 1 3 Turkey Vocel et al 2004 - 0.623 0.166 0.028 0.211 0.306 -0.124 0.893<br>1 3 Turkey - 0.225 0.120 0.014 -0.560 -0.207 0.007<br>UAE Faria et al 2019 - 0.454 0.137 0.019 -0.723 -0.164 -0.303 0.001<br>UAE Ibrahim et al 2019 - 0.454 0.137 0.019 -0.723 -0.164 -0.303 0.001<br>UAE Jamme et al 2019 - 0.454 0.177 0.031 -0.068 -0.201 -0.106 0.002<br>UAE Sharbab et al 2012 - 0.378 0.127 0.018 0.802  | 1               | urkey                       | Unalacak et al 2011                                | -0.504           | 0.229    | 0.052        | -0.952           | -0.055 | -2.199           | 0.028          |  |
| UAE Faria esi 2019 -0.454 0.137 0.019 -0.723 -0.184 -3.03 0.001  | 12              | urkey<br>urkey              | rucel et al 2004                                   | -0.023           | 0.168    | 0.028        | -0.351           | -0.090 | -0.134           | 0.893<br>0.807 |  |
| UAE         Jamar et al 2019         0.545         0.175         0.031         0.886         0.201         →           UAE         Stepsbe stat 2012         0.577         0.197         0.018         0.002         →           UAE         Stepsbe stat 2012         0.577         0.197         0.028         2978         0.002         →           UAE         0.449         0177         0.026         0.000         →   | IJ 🖞            | IAE<br>IAE                  | Faris et al 2019<br>Ibrahim et al 2008             | -0.454<br>-0.518 | 0.137    | 0.019        | -0.723           | -0.184 | -3.303           | 0.001          |  |
| UAE Stepade et al 2012 40.41% 0.127 40.11% 40.27% 0.003 7294 6.696 0.000 +   | Ŭ               | AE                          | Jamar et al 2019                                   | -0.545           | 0.175    | 0.031        | -0.885           | -0.201 | -3.108           | 0.002          |  |
|  | U<br>U          | IAE                         | orieneo et al 2012                                 | -0.378           | 0 127    | 0.016        | -0.603           | -0.294 | -5.696           | 0.003          |  |

Table 3 Characteristics of studies included in body weight change during Ramadan reviewed and analyzed as per the country included with three or more studies

| Component          | Country      | ĸa | N <sup>b</sup> | / <sup>2c</sup> (%) | Hedges' <i>g</i> (95%CI) <sup>d</sup> |
|--------------------|--------------|----|----------------|---------------------|---------------------------------------|
| Body weight change | Iran         | 22 | 1542           | 53.1                | - 0.305 (- 0.356 to - 0.254)          |
|                    | Jordan       | 7  | 480            | 0.001               | - 0.291 (- 0.434 to - 0.268)          |
|                    | Turkey       | 7  | 227            | 67.6                | - 0.301 (- 0.381 to - 0.200)          |
|                    | India        | 5  | 176            | 50.6                | - 0.291 (- 0.612 to - 0.304)          |
|                    | Malaysia     | 4  | 134            | 0.001               | - 0.291 (- 0.696 to - 0.341)          |
|                    | Pakistan     | 4  | 239            | 0.001               | - 0.291 (- 0.381 to - 0.002)          |
|                    | Saudi Arabia | 4  | 177            | 0.001               | - 0.148 (- 0.296 to - 0.200)          |
|                    | Tunisia      | 4  | 92             | 69.9                | - 0.297 (- 0.505 to - 0.089)          |
|                    | UAE          | 4  | 172            | 0.001               | - 0.449 (- 0.603 to - 0.294)          |

<sup>a</sup> K: denotes the number of studies

<sup>b</sup> N: denotes the number of participants

 $^{c}$  statistic describes the percentage of variation across studies due to heterogeneity rather than chance [162]

<sup>d</sup> CI, conidence interval

signiicant moderator in body weight loss induced by Rama-499 dan. In our analysis, the small efect size in body weight 500 (Hedges' g value of - 0.360, 95% CI - 0.405 to - 0.315) 501 equates to - 1.022 kg, which is less than the mean of weight 502 loss reported by the meta-analyses of Sadeghirad and col-503 leagues [32] and Fernando et al. [33], respectively. 504 The weight loss induced by Ramadan fasting observed 505 in the current analysis is the sum of reductions in both fat 506 masses (expressed in terms of body fat percent and absolute 507 fat mass), as well as fat-free mass as reported by Fernando 508

and colleagues [33]. This reduction in body weight and 509 body fat compartment induced by intermittent fasting dur-510 ing Ramadan is consistent with the body weight and body 511 fat reductions caused by other models of intermittent fasting 512 regimens [2, 93, 94]. 513

The relatively more significant reduction in body weight 514 reported during summer and autumn in comparison to win-515 ter is explained by the nature of Ramadan diurnal fasting. 516 which depends on the day hour fasting rather than night hour 517 fasting reported in other religions and intermittent fasting 518 regimens [95, 96]. Because the day hours' fasting during 519 520 Ramadan increases in summer (reaching 17 h), in comparison to winter (reaching 12 h), it becomes reasonable to lose 521 more weight at the end of Ramadan in the summer season, 522 vs. winter. Further, the higher temperature and humidity 523 during summer favors the reduction of body weight as a 524 result of the excessive sweating and more dehydrated state 525 [97]. However, considering the body weight loss is transient 526 527 during Ramadan [32, 33], it becomes pivotal to emphasize the importance of maintenance of weight loss after Rama-528 dan, and addressing the factors triggering weight gain after 529 530 Ramadan in research works.

531 In fact, according to the Islamic rules and instructions of the Prophetic Sunnah directed by the Prophet Mohammad 532 (PBUH), adult Muslims are encouraged to voluntarily fast 533 two days a week (namely Monday and Thursday), any six 534

days in the lunar or "Islamic" month of Shawwal (the month 535 after Ramadan, Hijri), the three full-moon days (13th, 14th, 536 and 15th days of each lunar month, Hijri), the Day of Ara-fah 537 (9th of Dhu'l - Hijja in the Islamic Hijri calendar), to fast as 538 often as possible in the two lunar months before Rama-dan 539 (Rajab and Sha'aban), and to fast the irst nine days of Dhu'l-540 Hijia in the lunar Islamic calendar for those who are not 541 performing Hajj (the pilgrimage to Makkah) [98, 99]. 542 Practicing such voluntary fasting after Ramadan has been 543 reported to maintain weight loss and to improve metabolic 544 markers and food intakes among overweight and obese 545 adult Muslims [98, 100, 101], an efect that may extend for six 546 months after Ramadan [100]. 547

The heterogeneity of the studies included in the cur-rent 548 meta-analysis for the body weight could be ascribed to variable 549 efects and confounding factors, and due to several 550 inconsistencies in designing, conducting, and interpreting 551 results of the studies undertaken during Ramadan. It is con-552 ceivable that a critical violation that many fasting people do 553 during Ramadan is skipping a pre-dawn meal (suhoor), a matter 554 that could contribute to a signiicant daily caloric deicit, and would 555 be expected to promote metabolic abnor-malities, increased postprandial insulin levels, increased fat oxidation, and 557 conceivably confound the incumbent results [103]. Further, variable changes in lifestyle behaviors such as physical activity 559 and sleep patterns [102, 103] accom-panying the fasting month 560 of Ramadan may impact body weight changes. Thus, future 561 research has to consider all the covariables mentioned above 562 and to control the interfering factors that may hinder Ramadan 563 research results in less accurate, especially total caloric and 565 dietary intakes, physi-cal activity and sleep patterns.

Strengths of the current review stems from that it is the 567 one with the largest number of harvested and analyzed arti-568 cles ever published in the literature on Ramadan and body 569 570 weight changes. Second, the strict inclusion and exclusion

| Name         Name <th< th=""><th>Group by</th><th>Study name</th><th></th><th>_</th><th>Statistics fo</th><th>or each s</th><th>tudy</th><th></th><th></th><th>Hedges's g and 95% CI</th></th<>  | Group by         | Study name                                       |               | _                 | Statistics fo | or each s      | tudy           |         |         | Hedges's g and 95% CI |
|--|------------------|--|---------------|-------------------|---------------|----------------|----------------|---------|---------|-----------------------|
| Adam       Result al 200       404       922       004       407       0.92       1.11       0.95       1  | Season           |  | Hedges's<br>g | Standard<br>error | Variance      | Lower<br>limit | Upper<br>limit | Z-Value | p-Value |                       |
| Atoma         Absolution         Advance         Figure 14 (200)         -1440         0550         -1440         0550         -1440           Atoma         Figure 14 (200)         -010            | Autumn           | Ramadan 2002                                     | -0.483        | 0.252             | 0.064         | -0.977         | 0.012          | -1.914  | 0.056   |                       |
| Addres       Product at a John       0.27       0.12       0.21       0.24       0.20       0.26       0.25   | Autumn           | Afrasiabi et al 2003                             | -0.483        | 0.252             | 0.064         | -0.977         | 0.012          | -1.914  | 0.056   |                       |
| Name         Number af John         Olds  | Autumn           | Kassab et al 2003<br>Fakhrzadeh et al 2003       | -0.286        | 0.151             | 0.023         | -0.582         | -0.010         | -1.892  | 0.058   |                       |
| Adam         Remark et al 2014         0.81         0.921         0.931  | Autumn           | Yucel et al 2004                                 | -0.023        | 0.168             | 0.028         | -0.351         | 0.306          | -0.134  | 0.893   |                       |
| Adam       Katas is d Jobit       0.10       0.12       0.10       0.   | Autumn           | Rahman et al 2004                                | -0.834        | 0.252             | 0.063         | -1.327         | -0.340         | -3.309  | 0.001   |                       |
| Partmeter         Persubart at 2000         100         220         120         230         127         Loop   | Autumn           | Kassab et al 2004<br>Aksungar et al 2005         | -0.077        | 0.145             | 0.021         | -0.361         | 0.208          | -0.527  | 0.598   |                       |
| Allen       Allen <t< td=""><td>Autumn</td><td>Farshidfar et al 2006</td><td>-1.016</td><td>0.263</td><td>0.042</td><td>-1.529</td><td>-0.502</td><td>-3.877</td><td>0.000</td><td></td></t<>  | Autumn           | Farshidfar et al 2006                            | -1.016        | 0.263             | 0.042         | -1.529         | -0.502         | -3.877  | 0.000   |                       |
| Attam         Zost H al 2005         0.71   | Autumn           | Al-Numair 2006                                   | -0.295        | 0.150             | 0.022         | -0.589         | -0.002         | -1.971  | 0.049   |                       |
| Dathmen         Diskhan et al bolog         0.00         0.14         0.02 <th0.02< th="">         0.0</th0.02<>  | Autumn           | Ziaee et al 2006                                 | -0.376        | 0.114             | 0.013         | -0.599         | -0.153         | -3.300  | 0.001   |                       |
| Autom         Bishis and heights 2007         0.70         0.20         0.80         0.80         1           Autom         Marcina 2007         0.20 <t< td=""><td>Autumn</td><td>Subhan et al 2006</td><td>-0.307</td><td>0.174</td><td>0.030</td><td>-0.598</td><td>-0.235</td><td>-2.065</td><td>0.039</td><td></td></t<>  | Autumn           | Subhan et al 2006                                | -0.307        | 0.174             | 0.030         | -0.598         | -0.235         | -2.065  | 0.039   |                       |
| Adam         At-Instant advant 207         Adda         Adam   | Autumn           | Salehi and Neghab 2007                           | -0.678        | 0.205             | 0.042         | -1.079         | -0.276         | -3.309  | 0.001   |                       |
| Halm 2007         Color         Color <thcolor< th="">         Color         Color</thcolor<>  | Autumn           | Al- Hourani and Atoum 2007                       | -0.262        | 0.133             | 0.018         | -0.522         | -0.001         | -1.969  | 0.049   |                       |
| Augum         Modal of 2027         0.01         0.09  | Autumn           | Mansi 2007<br>Mansi and Amneh 2007               | -0.247        | 0.120             | 0.014         | -0.483         | -0.012         | -2.061  | 0.039   |                       |
| Alamm         Istalm # aloos         0.410         0.120         0.120         0.120         0.120         0.120         0.120         0.120           Alamm         Land Standy of al 2000         0.430         0.030         0.410         0.120  | Autumn           | Moosavi et al 2007                               | -0.310        | 0.094             | 0.009         | -0.494         | -0.126         | -3.297  | 0.001   | -                     |
| Adamm         Dihutebrandi el 2020         -0.40         0.00         0.727         -0.18         -0.20         0.001         -1           Sering         Axia and Rescue 1197         -0.69         0.339         0.115         -1.32         0.001         -1.46         0.021         -1.47         0.001         0.221         0.001 <td< td=""><td>Autumn</td><td>Ibrahim et al 2008</td><td>-0.518</td><td>0.270</td><td>0.073</td><td>-1.047</td><td>0.011</td><td>-1.920</td><td>0.055</td><td></td></td<>   | Autumn           | Ibrahim et al 2008                               | -0.518        | 0.270             | 0.073         | -1.047         | 0.011          | -1.920  | 0.055   |                       |
| Allamba         Lamba         Lamba <thlamba< th="">         Lamba         Lamba         <t< td=""><td>Autumn</td><td>Shariatpanahi et al 2007</td><td>-0.463</td><td>0.140</td><td>0.020</td><td>-0.737</td><td>-0.188</td><td>-3.303</td><td>0.001</td><td></td></t<></thlamba<>   | Autumn           | Shariatpanahi et al 2007                         | -0.463        | 0.140             | 0.020         | -0.737         | -0.188         | -3.303  | 0.001   |                       |
| Spring<br>Gyng         Actia or Bascel 1007         0.69         0.336         0.115         -1.22         0.005         -1.24         0.005         -1.24         0.005         -1.24         0.005         -1.24         0.005         -1.24         0.005         -1.24         0.005         -1.24         0.005         0.001         -1.24         0.005         0.001         -1.24         0.001         -1.24         0.001         -1.24         0.001         -1.24         0.001         -1.24         0.001         -1.24         0.001         0.  | Autumn           | Lamri-Sennadji et al 2009                        | -0.243        | 0.147             | 0.022         | -0.532         | 0.045          | -1.654  | 0.098   |                       |
| Spring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring<br>Bring | Spring           | Azizi and Rasouli 1987                           | -0.659        | 0.339             | 0.115         | -1.323         | 0.005          | -1.945  | 0.052   |                       |
| Bring  | Spring           | Takruri 1989                                     | -0.286        | 0.087             | 0.008         | -0.456         | -0.116         | -3.296  | 0.001   |                       |
| Determine         Product and 1962,<br>Determine         0.44         0.420         0.430         0.440         <  | Spring           | Fadeil at al 1000                                | -0.329        | 0.119             | 0.014         | -0.562         | -0.095         | -2.759  | 0.006   |                       |
| Bummer         Pathas and Path 2010         0.491         0.197         0.295         -3.390         0.091           Summer         Assad st 2011         0.619         0.224         4.264         0.611         0.619           Summer         Assad st 2011         0.629         0.52         0.224         4.264         0.611         0.614           Summer         Assad st 2011         0.629         0.625         0.656         0.601         1.171         0.644         0.611           Summer         Fairs st 2012         0.310         0.227         0.228         0.026         0.031         1         1         1         1         1         1         1         1         1         1         1         1         1         0.227         0.239         0.031         1         1         1         1         1         0.227         0.239         0.031         1         1         1         0.247         0.031         1         1         1         0.247         0.031         1         1         1         1         0.247         0.031         1         1         1         0.027         0.021         0.011         1         1         1         0.027         0.021 </td <td>Summer</td> <td>Norouzy et al 2010</td> <td>-0.744</td> <td>0.225</td> <td>0.050</td> <td>-1.184</td> <td>-0.303</td> <td>-3.310</td> <td>0.001</td> <td></td>  | Summer           | Norouzy et al 2010                               | -0.744        | 0.225             | 0.050         | -1.184         | -0.303         | -3.310  | 0.001   |                       |
| Summer         Abesimmer   | Summer           | Pathan and Patil 2010                            | -0.651        | 0.197             | 0.039         | -1.036         | -0.265         | -3.309  | 0.001   |                       |
| Bummer Assa. et al 2011 - 0.029 0.13 0.017 -0.28 0.22 -0.26 0.28 0.29 -0.27 0.00 -0.29 0.29 0.29 0.29 0.29 0.29 0.29 0.29  | Summer           | Abedelmalek et al 2011                           | -1.518        | 0.468             | 0.219         | -2.434         | -0.601         | -3.246  | 0.001   |                       |
| commen         comment         comment <thcomment< th=""> <thcomment< th=""> <thco< td=""><td>Summer</td><td>Assadi et al 2011</td><td>-0.029</td><td>0.130</td><td>0.017</td><td>-0.283</td><td>0.225</td><td>-0.226</td><td>0.821</td><td></td></thco<></thcomment<></thcomment<>  | Summer           | Assadi et al 2011                                | -0.029        | 0.130             | 0.017         | -0.283         | 0.225          | -0.226  | 0.821   |                       |
| Dammer         Fairs et 29:12b         -0.427         0.148         0.022         0.077         -118         0.071         -11           Summer         Sheba et al 2012         -0.378         0.222         0.051         -2.978         0.000         -1         -1           Summer         Developile et al 2013         -0.595         0.143         0.227         -0.397         -0.900         0.001         -1         -1           Summer         Developile et al 2013         -0.595         0.101         0.022         -0.801         -2.878         0.001         -1  | Summer           | Faris et al 2012                                 | -0.504        | 0.229             | 0.052         | -0.952         | -0.055         | -2.199  | 0.028   |                       |
| Summer         Khada id 2012         0.051         0.127         0.161         0.17         0.161           Summer         Apount el 2013         0.559         0.127         0.161         0.227         0.280         0.287         0.290         0.001         1           Summer         Apount el 2013         0.559         0.143         0.222         0.278         0.001         1         1           Summer         Hossavid el 2013         0.216         0.016         0.022         0.017         0.018         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         0.011         1         1         1         1         1         1         1         1         1         1         0.011         1         1         0.011         1         1         1         0.011         1         1         0.011         1         1         0.011         1         0.011         0.011         0.011         0.011         0.011         0.011         0.011         0.011         0.011         0.011         0.011         0.011         1         1         0.011         <  | Summer           | Faris et al 2012b                                | -0.487        | 0.148             | 0.022         | -0.777         | -0.198         | -3.304  | 0.001   |                       |
| Summer Shehab et al 2012 - 0.778 0.127 0.014 0.027 - 0.129 - 2.978 0.033   | Summer           | Khattak et al 2012                               | -0.834        | 0.252             | 0.063         | -1.327         | -0.340         | -3.309  | 0.001   |                       |
| Bummer Pageum Bal 2013<br>Summer Hosseni al 2013<br>Summer Bohn al 2014<br>Summer Abophab i al 2014<br>Summer Abophab i al 2014<br>Summer Abophab i al 2014<br>Summer Celli et al 2014<br>Summer Hosseni al 2015<br>Summer Bohn al 2015<br>Summer Bohn al 2014<br>Summer Abophab i al 2014<br>Summer Celli et al 2014<br>Summer Bohn al 2015<br>Summer Bohn al 2016<br>Summer Celli et al 2014<br>Summer Bohn al 2016<br>Summer Bohn al 2017<br>Summer Bohn al 2016<br>Summer Bohn al 2016<br>Summer Bohn al 2017<br>Summer Bohn al 2016<br>Summer Siparate Al 2017<br>Summer Bohn al 2016<br>Summer Bohn al 2016<br>Summer Bohn al 2016<br>Summer Siparate Al 2017<br>Summer Bohn al 2016<br>Summer Bohn al 2017<br>Summer Bohn  | Summer           | Shehab et al 2012                                | -0.378        | 0.127             | 0.016         | -0.627         | -0.129         | -2.978  | 0.003   | _                     |
| Summer         Hassar et al 2013         -0.202         0.011         -1.644         0.058           Summer         Norsar et al 2013         -0.217         0.398         0.011         -1.644         0.058           Summer         Norsar et al 2013         -0.217         0.398         0.014         -0.244         0.081         -1.7           Summer         Norsar et al 2013         -0.217         0.244         0.037         -2.244         0.001         -1.7           Summer         Narsar et al 2014         0.518         0.271         0.747         1.583         0.529         -1.145         0.222         -1.145         0.227         0.001         -1.145         0.227         0.011         -1.145         0.227         0.011         -1.145         0.228         0.011         -1.145         0.227         0.011         -1.145         0.228         0.011         -1.145         0.228         0.011         -1.145         0.228         0.011         -1.145         0.228         0.011         -1.145         0.228         0.011         -1.145         0.228         0.011         -1.145         0.228         0.011         -1.145         0.228         0.011         -1.147         0.228         0.011         -1.147         <   | Summer           | Agoumi et al 2013<br>Develio du et al 2013       | -0.559        | 0.143             | 0.021         | -0.839         | -0.278         | -3.900  | 0.000   |                       |
| Summer         Hosseni el al 2013         -1.27         0.399         0.152         2.240         -0.514         0.279         0.001           Summer         Rohn et al 2013         -0.510         0.154         0.024         -0.519         0.154         0.026         0.001           Summer         Rohn et al 2013         -0.510         0.214         0.028         0.001         -1.45         0.225         0.000           Summer         Alzophalo et al 2014         -0.370         0.122         0.016         0.217         0.016         0.217         0.016         0.017         -1.45         0.226         0.005         0.001         -1.45         0.226         0.001         0.011         0.011         0.011         0.011         0.012         0.011         0.012         0.011         0.012         0.011         0.012         0.011         0.012         0.011         0.012         0.011         0.012         0.011         0.012         0.011         0.012         0.012         0.011         0.012         0.012         0.011         0.012         0.012         0.012         0.011         0.012         0.012         0.012         0.012         0.012         0.012         0.012         0.012         0.012 <td< td=""><td>Summer</td><td>Haouari-Oukerro et al 2013</td><td>-0.308</td><td>0.163</td><td>0.027</td><td>-0.627</td><td>0.011</td><td>-1.894</td><td>0.058</td><td></td></td<>   | Summer           | Haouari-Oukerro et al 2013                       | -0.308        | 0.163             | 0.027         | -0.627         | 0.011          | -1.894  | 0.058   |                       |
| Summer Norozy et al 2013 - 0.214 0.065 0.044 0.027 0.067 0.228 0.001   | Summer           | Hosseini et al 2013                              | -1.277        | 0.389             | 0.152         | -2.040         | -0.514         | -3.279  | 0.001   |                       |
| Bummer Kom at 2013 - 10.510 0.124 0.024 4.513 - 2.019 0.001  | Summer           | Norouzy et al 2013                               | -0.214        | 0.065             | 0.004         | -0.342         | -0.087         | -3.294  | 0.001   |                       |
| Summer         Abgustative if al 2014         -0.376         0.328         0.108         -0.108         0.227         -1.445         0.222           Summer         Cansel et al 2014         -0.537         0.162         0.024         0.170         0.166         0.024         0.170         0.016         0.048         0.170         0.016         0.048         0.170         0.016         0.048         0.170         0.016         0.048         0.176         0.010         0.011         0.011         0.016         0.011         0.012         0.016         0.014         0.016         0.014         0.016         0.014         0.016         0.014         0.016   | Summer           | Rohin et al 2013<br>Savedda et al 2013           | -0.510        | 0.154             | 0.024         | -0.813         | -0.208         | -3.305  | 0.001   |                       |
| Summer         Carsel et al 2014         0.170         0.169         0.024         0.157         0.162         0.024         0.051         0.024           Summer         Fetoslihazach et al 2014         0.051         0.015         0.016         0.011         0.015         0.016         0.012         0.015         0.016         0.012         0.015         0.016         0.012         0.015         0.016         0.012         0.016         0.012         0.016         0.012         0.016         0.012         0.016         0.012         0.016         0.012         0.016         0.012         0.016         0.012         0.016         0.012         0.016         0.012         0.016         0.012         0.016         0.012         0.016         0.012         0.016         0.012         0.016         0.012         0.016         0.012         0.016         0.012         0.016         0.012         0.016         0.000   | Summer           | Alzoghaibi et al 2014                            | -0.376        | 0.328             | 0.108         | -1.018         | 0.267          | -1.145  | 0.252   |                       |
| Summer         Cellic et al 2014         -0.637         0.162         0.028         -0.635         -0.219         -0.306         0.001           Summer         Hassan and Isavum 2014         -0.166         0.122         0.011         -0.428         0.151           Summer         Hassan and Isavum 2014         -0.160         0.022         0.084         0.746         0.116         -0.128         0.154           Summer         Salahuddin and Javed 2014         -0.221         0.084         0.767         0.112         -1.268         0.208           Summer         Ganou et al 2015         -0.414         0.013         -0.017         -0.112         -2.007         0.009           Summer         Ganou et al 2015         -0.421         0.021         -0.017         -0.112         -2.007         0.009           Summer         Summer al 2015         -0.526         0.021         -0.017         -0.124         -0.2145         -0.201         -0.214         -0.218         0.001         -1.111         -0.217         -0.019         -0.218         0.000         -0.019         -0.218         0.000         -0.019         -0.218         0.000         -0.010         -0.019         -0.010         -0.019         -0.010         -0.010  | Summer           | Cansel et al 2014                                | 0.170         | 0.156             | 0.024         | -0.137         | 0.476          | 1.085   | 0.278   |                       |
| Summer Personalization et al. 2014 0.440 0.123 0.013 0.024 0.019 0.330 0.001 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1   | Summer           | Celik et al 2014                                 | -0.537        | 0.162             | 0.026         | -0.855         | -0.219         | -3.306  | 0.001   |                       |
| Summer Balandman diaved 2014 - 0.314 0.220 0.040 - 0.746 0.119 - 1.426 0.154 0.54 0.554 0.258 0  | Summer           | Hassan and Isawumi 2014                          | -0.406        | 0.123             | 0.015         | -0.048         | 0.091          | -3.301  | 0.001   |                       |
| Summer Babundain and Javed 2014 028 0.160 0.022 0.581 0.125 -1266 0.208 0.009 0.009 0.009 0.009 0.009 0.009 0.009 0.009 0.009 0.009 0.009 0.009 0.009 0.009 0.009 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000  | Summer           | McNeil et al 2014                                | -0.314        | 0.220             | 0.049         | -0.746         | 0.118          | -1.425  | 0.154   |                       |
| Summer         Begum et al 2015         -0.414         0.018         -0.703         -0.176         -0.122         2.2007         0.001           Summer         Hosseini and Heijad 2015         -0.421         0.203         0.014         -0.818         -0.023         -2.007         0.009           Summer         Lidex-Elucene et al 2015         -0.522         0.124         0.018         -0.725         -2.200         0.001  | Summer           | Salahuddin and Javed 2014                        | -0.228        | 0.180             | 0.032         | -0.581         | 0.125          | -1.265  | 0.206   |                       |
| Burmmer Hossenia na Hejazi 2015 - 0.421 0.230 0.045 -1.076 -0.122 -2.076 0.039<br>Summer Lógez Bueno et al 2015 - 0.421 0.230 0.041 -0.818 -0.022 -2.076 0.039<br>Summer Suman et al 2015 - 0.421 0.018 0.012 -0.570 -0.145 -3.289 0.000<br>Summer Suman et al 2015 - 0.388 0.147 0.022 -0.670 -0.099 -2.628 0.009<br>Summer Bahammam et al 2016 -0.122 0.111 0.012 -0.341 0.025 -0.001  | Summer           | Begum et al 2015                                 | -0.441        | 0.134             | 0.018         | -0.703         | -0.179         | -3.302  | 0.001   | _                     |
| Summer         López-Bueno et al 2015         0.622         0.134         0.016         0.725         0.230         -3.290         0.000           Summer         Suriani et al 2015         -0.358         0.101         0.122         -0.570         -0.485         -2.259         0.010         0.111           Summer         Tailo et al 2015         -0.400         0.152         0.022         -0.670         -0.493         -2.589         0.010         0.111           Summer         Bahamman et al 2016         -0.123         0.012         -0.893         -2.589         0.001         0.111           Summer         Ganjal et al 2016         -0.517         0.160         0.024         -0.823         -0.210         -3.305         0.001           Summer         Nugraha et al 2017         -1.010         0.344         0.121         -3.310         0.000         0.011           Summer         Habid al 2017         -0.029         0.115         0.013         -0.810         0.051         -1.657         0.939         0.930         0.930         0.935         0.930         0.901         -1.44         0.942         0.930         0.935         0.935         0.935         0.935         0.935         0.935         0.935 <td< td=""><td>Summer</td><td>Hosseini and Heiazi 2015</td><td>-0.014</td><td>0.230</td><td>0.055</td><td>-0.818</td><td>-0.023</td><td>-2.007</td><td>0.009</td><td></td></td<>   | Summer           | Hosseini and Heiazi 2015                         | -0.014        | 0.230             | 0.055         | -0.818         | -0.023         | -2.007  | 0.009   |                       |
| Summer         Sigwandi et al 2015         -0.38         0.108         0.014         -0.32         0.001           Summer         Table et al 2015         -0.381         0.147         0.022         -0.670         -0.014         5.289         0.010           Summer         Table et al 2015         -0.400         0.152         -0.670         -0.035         0.009         -1.14         0.229         -0.870         -0.144         -0.229         0.001         -1.14         0.229         0.201         -3.305         0.001         -1.14         -1.14         0.229         0.201         -3.305         0.001         -1.14         0.229         0.201         -3.305         0.001         -1.14         0.229         0.201         -3.305         0.001         -1.14         0.229         0.201         -3.305         0.001         -1.14         0.229         0.015         0.011         0.015         0.011         0.035         0.000   | Summer           | López-Bueno et al 2015                           | -0.522        | 0.134             | 0.018         | -0.785         | -0.260         | -3.900  | 0.000   | _                     |
| Summer Suran et al 2015 0.481 0.147 0.022 0.670 0.093 2.289 0.010 Summer Tailo et al 2015 0.400 0.152 0.022 0.689 0.010 Summer Bahammam et al 2016 0.512 0.012 0.280 0.010 0.22808 0.001 Summer Symmet Id 2016 0.551 0.168 0.024 0.823 0.210 3.305 0.001 Summer Nugrahe et al 2017 0.025 0.297 0.088 1.208 0.042 0.23 0.000 Summer AbduKareen et al 2017 0.025 0.297 0.088 1.208 0.042 0.23 0.000 Summer AbduKareen et al 2017 0.025 0.297 0.088 1.208 0.042 0.23 0.000 Summer Khan et al 2017 0.025 0.297 0.088 1.028 0.042 0.23 0.000 Summer Khan et al 2017 0.002 0.115 0.013 0.316 0.133 0.080 0.423 Summer Khan et al 2017 0.025 0.113 0.013 0.316 0.133 0.080 0.423 Summer Khan et al 2017 0.025 0.113 0.013 0.518 0.055 0.997 Summer Khan et al 2017 0.217 0.113 0.018 0.051 1.857 0.997 Summer Khan et al 2017 0.229 0.169 0.028 0.810 0.051 1.857 0.997 Summer Latir et al 2017 0.229 0.169 0.028 0.810 0.051 0.185 0.090 Summer Khan et al 2017 0.229 0.160 0.014 0.557 0.280 0.011 - Summer Latir et al 2017 0.255 0.124 0.015 0.478 0.002 0.091 Summer Mohammadzade et al 2017 0.255 0.124 0.015 0.478 0.003 1.075 0.283 Summer Mohammadzade et al 2017 0.245 0.1292 0.028 0.001   | Summer           | Sijavandi et al 2015                             | -0.358        | 0.108             | 0.012         | -0.570         | -0.145         | -3.299  | 0.001   |                       |
| Dummer         Bahammar et al 2015         -0.100         0.122         0.024         0.025         0.102         0.020         0.029         -1.040         0.289           Summer         Ganjali et al 2016         -0.517         0.156         0.022         -0.210         -3.305         0.001           Summer         Sym et al 2017         -1.078         0.246         0.081         -0.218         -3.305         0.001           Summer         Nugraha et al 2017         -0.107         0.226         0.044         -0.216         -3.305         0.000           Summer         Abulkarement et al 2017         -0.078         0.208         -0.424         -2.103         0.035           Summer         Bakki et al 2017         -0.027         0.168         0.023         -0.610         0.051         -1.657         0.097           Summer         Khan et al 2017         -0.267         0.113         0.013         -0.350         -0.025         -3.09         0.001         -0.025           Summer         Mohammatcade et al 2017         -0.563         0.286         -3.289         0.001         -0.025         -3.090         0.001         -0.025         -3.090         0.001         -0.026         -0.023         -0.024 <t< td=""><td>Summer</td><td>Suriani et al 2015</td><td>-0.381</td><td>0.147</td><td>0.022</td><td>-0.670</td><td>-0.093</td><td>-2.589</td><td>0.010</td><td></td></t<>   | Summer           | Suriani et al 2015                               | -0.381        | 0.147             | 0.022         | -0.670         | -0.093         | -2.589  | 0.010   |                       |
| Summer         Ganjali et al 2016         -0.517         0.168         0.024         -0.823         -0.216         -3.305         0.001           Summer         Syam et al 2017         -1.078         0.246         0.024         -0.215         -3.305         0.001           Summer         AbdulKarem et al 2017         -0.022         0.297         0.088         -2.103         0.005           Summer         AbdulKarem et al 2017         -0.022         0.227         0.286         -2.682         0.008         -4.373           Summer         Hakutheen et al 2017         -0.029         0.115         0.133         -0.256         -2.682         0.009           Summer         Khan et al 2017         -0.027         0.113         0.015         -1.657         0.026         0.980         -4.333           Summer         Malkemakan et al 2017         -0.050         0.181         0.033         -0.255         0.390         0.001         -4.333         0.001           Summer         Malkemakan et al 2017         -0.651         0.197         0.038         -0.426         -3.309         0.001         -4.333         0.001         -4.333         0.051         -4.333         0.051         -4.333         0.051         -4.333   | Summer           | Bahammam et al 2016                              | -0.400        | 0.152             | 0.023         | -0.341         | 0.095          | -2.020  | 0.269   |                       |
| Summer         Syam et al 2016         -0.530         0.160         0.028         -0.844         -0.216         -0.305         0.001           Summer         Nugrahe et al 2017         -0.625         0.297         0.088         -1.208         -0.042         -2.103         0.0035           Summer         Abubheen et al 2017         -0.062         0.297         0.088         -0.256         -2.832         0.0035           Summer         Backi et al 2017         -0.029         0.116         0.133         -0.216         0.0423           Summer         Khan et al 2017         -0.279         0.118         0.033         -0.516         0.097           Summer         Khan et al 2017         -0.025         0.111         0.033         -0.519         -0.500         0.001           Summer         Latri et al 2017         -0.661         0.197         -0.135         -3.309         0.001         -1           Summer         Mohammadzade et al 2017         -0.651         0.197         0.038         -0.106         0.125         -3.309         0.001         -1           Summer         Mohammadzade et al 2017         -0.255         0.124         0.104         0.035         -3.039         0.001           Sum   | Summer           | Ganjali et al 2016                               | -0.517        | 0.156             | 0.024         | -0.823         | -0.210         | -3.305  | 0.001   |                       |
| Summer         Nugraha et al 2017         -1.078         0.246         0.001         -1.511         -1.038         -0.042         -2.138         0.008         -1.038         -0.042         -2.138         0.008         -1.038         0.028         -1.038         0.042         -2.138         0.008         -1.038         0.028         -0.080         1.042         -2.208         0.0097         -1.138         0.033         -0.558         -0.075         -2.120         0.0097         -1.138         0.038         -1.036         -2.255         -3.399         0.001         -1.138         1.927         0.054         -1.138         1.927         0.054         -1.138         1.927         0.054         -1.138         1.927         0.054         -1.138         1.927         0.054         -1.138         1.927         0.054   | Summer           | Syam et al 2016                                  | -0.530        | 0.160             | 0.026         | -0.844         | -0.216         | -3.305  | 0.001   |                       |
| Jummer         Asubheen et al 2017         -0.010         0.341         0.167         -0.753         -0.256         2.632         0.008           Summer         Bakki et al 2017         -0.092         0.115         0.013         -0.316         -0.832         0.008           Summer         Khan et al 2017         -0.297         0.113         0.013         -0.316         -0.075         -2.620         0.009           Summer         Latir et al 2017         -0.005         0.118         0.003         -0.350         -0.025         0.390           Summer         Maleknakan et al 2017         -0.651         0.197         0.039         -1.035         -3.299         0.001   | Summer<br>Summer | Nugraha et al 2017<br>AbdulKareem et al 2017     | -1.078        | 0.246             | 0.061         | -1.561         | -0.595         | -4.373  | 0.000   |                       |
| Summer       Bakki et al 2017       -0.092       0.115       0.013       -0.316       0.133       0.800       0.423         Summer       Khan et al 2017       -0.279       0.119       0.028       -0.015       -1.857       0.009         Summer       Latir et al 2017       -0.005       0.111       0.003       -0.350       -0.025       0.980         Summer       Malekmakan et al 2017       -0.661       0.197       0.039       -1.036       -0.256       -3.309       0.001         Summer       Mohammadzade et al 2017       -0.651       0.197       0.039       -1.036       -0.256       -3.309       0.001         Summer       Norsuzy et al 2017       -0.226       0.124       0.015       -1.888       0.059         Summer       Norsuzy et al 2017       -0.226       0.028       -0.011       -1.885       0.059         Summer       Roy and Bandyopadhyay 2017       -0.167       0.028       -0.028       -0.013       -1.986       0.001         Summer       Nachwa et al 2018       -0.027       0.014       -0.223       -0.84       -0.013       0.990       -0.11       -1.885       0.598       -0.11       -1.886       0.001       -0.11       -1.895       <   | Summer           | Alsubheen et al 2017                             | -1.010        | 0.384             | 0.147         | -1.763         | -0.258         | -2.632  | 0.008   |                       |
| Summer         Knan et al 2017         -0.279         0.169         0.028         -0.610         0.051         -1.857         0.097           Summer         Latiri et al 2017         -0.005         0.181         0.033         -0.559         0.526         0.009           Summer         Malekmakan et al 2017         -0.056         0.106         0.011         -0.557         -0.142         -3.299         0.001           Summer         Molasmadzade et al 2017         -0.563         0.282         -0.085         -0.0142         -3.299         0.001           Summer         Norouzy et al 2017         -0.256         0.104         -0.155         -0.124         -0.309         -0.083           Summer         Pallayoxa et al 2017         -0.236         0.124         0.015         -0.175         0.283           Summer         Royand Bandyopadhyay2017         -0.246         0.202         -0.284         -0.013         0.990  | Summer           | Bakki et al 2017                                 | -0.092        | 0.115             | 0.013         | -0.316         | 0.133          | -0.800  | 0.423   |                       |
| Summer         Latifier is al 2017         -0.287         0.113         -0.013         -0.016         0.013         -0.016         0.0010           Summer         Malekmakan et al 2017         -0.350         0.350         -0.255         -3.289         0.001           Summer         Mohammadzade et al 2017         -0.561         0.197         0.039         -1.036         -0.255         -3.399         0.001           Summer         Mohammadzade et al 2017         -0.563         0.229         0.035         -0.101         1.135         1.277         0.054           Summer         Ongsara et al 2017         -0.235         0.1167         0.028         -0.009         -1.888         0.059           Summer         Pallayova et al 2017         -0.236         0.122         0.052         -0.684         0.009         -1.888         0.058           Summer         Rolandyagathyay 2017         -0.317         0.167         0.022         0.228         -0.010         -1.990           Summer         Nachwak et al 2018         -0.021         0.002         0.0027         -0.184         -3.303         0.001           Summer         Faris et al 2019         -0.454         0.175         0.012         -1.914         0.057  | Summer           | Khan et al 2017<br>Kivoni et al 2017             | -0.279        | 0.169             | 0.028         | -0.610         | 0.051          | -1.657  | 0.097   |                       |
| Summer         Malekmakan et al 2017         -0.350         0.106         0.011         -0.557         -0.142         -3.289         0.001           Summer         Mohammadzade et al 2017         -0.661         0.197         0.039         -1.036         -0.265         -3.309         0.001           Summer         Norouzy et al 2017         -0.251         0.112         0.015         -0.478         0.009         -1.888         0.059           Summer         Ongsara et al 2017         -0.246         0.229         0.052         -0.540         0.001         -1.185         0.283           Summer         Rolad Bandyopadhyay 2017         -0.170         0.167         0.282         0.052         -0.540         0.011         -1.955         0.233           Summer         Rolad Bandyopadhyay 2017         -0.170         0.168         0.001  | Summer           | Latiri et al 2017                                | -0.297        | 0.113             | 0.013         | -0.518         | -0.075         | -2.620  | 0.009   |                       |
| Summer         Mohammadzade et al 2017         -0.661         0.197         0.039         -1.036         -0.265         -3.309         0.001           Summer         Norouzy et al 2017         -0.236         0.292         0.085         -0.010         1.135         1.927         0.054           Summer         Pollayova et al 2017         -0.236         0.124         0.015         -0.778         0.009         -           Summer         Pallayova et al 2017         -0.246         0.229         0.052         -0.645         0.011         1.185         0.058           Summer         Roy and Bandyopadhyay 2017         -0.317         0.167         0.022         -0.024         0.003         -0.990           Summer         Nachwak et al 2018         -0.002         0.148         0.002         -0.110         -3.296         0.001           Summer         Faris et al 2019         -0.454         0.137         0.019         -0.227         0.019         -0.21           Summer         Haghlight et al 2019         -0.454         0.137         0.019         -0.228         0.021         -3.018         0.001           Summer         Haghlight et al 2019         -0.454         0.171 <th0.229< th="">         -0.229         3.889&lt;</th0.229<>  | Summer           | Malekmakan et al 2017                            | -0.350        | 0.106             | 0.011         | -0.557         | -0.142         | -3.299  | 0.001   |                       |
| Summer         Norouzy et al 2017         0.563         0.292         0.085         -0.010         1.135         1.927         0.054           Summer         Ongasa et al 2017         -0.236         0.124         0.005         -0.488         0.009         -1.888         0.059           Summer         Pallayoxa et al 2017         -0.246         0.229         0.052         -0.694         0.203         -1.075         0.283           Summer         Roy and Bandyopadhyay 2017         -0.317         0.167         0.028         -0.494         0.013         0.190           Summer         Nachwa et al 2018         -0.020         0.148         0.022         -0.292         0.288         0.013         0.990           Summer         Nachwa et al 2019         -0.454         0.137         0.012         -1.001         -3.296         0.001         -           Summer         Farse tya and Sapwarobol 2018         -0.630         0.200         0.044         -1.03         -0.282         -3.300         0.001         -           Summer         Farse tya and Sapwarobol 2018         -0.640         0.118         -0.217         -0.104         -3.030         0.001         -         -           Summer         Haghighi et al 2019 <td>Summer</td> <td>Mohammadzade et al 2017</td> <td>-0.651</td> <td>0.197</td> <td>0.039</td> <td>-1.036</td> <td>-0.265</td> <td>-3.309</td> <td>0.001</td> <td></td>   | Summer           | Mohammadzade et al 2017                          | -0.651        | 0.197             | 0.039         | -1.036         | -0.265         | -3.309  | 0.001   |                       |
| Summer         Pailsgive at al 2017         -0.230         0.124         0.0105         -0.476         0.0205         -1.888         0.039           Summer         Pailsgive at al 2017         -0.246         0.229         0.052         -0.084         0.203         -1.075         0.283           Summer         Roy and Bandyopadhyay 2017         -0.317         0.167         0.028         -0.045         0.011         -1.885         0.058           Summer         AL-barin and Aljaloud 2018         -0.002         0.144         0.022         -0.292         0.329         0.001         -           Summer         Praseba and Sapwarobol 2018         -0.693         0.209         0.044         -1.103         -0.282         -3.309         0.001         -           Summer         Prais et al 2019         -0.454         0.137         0.0176         0.012         -1801         0.057         -           Summer         Jarrar et al 2019         -0.264         0.021         -3.108         0.000         -         -           Summer         Rahbar et al 2019         -0.268         0.017         -0.229         -3.899         0.000         -         -           Summer         Alan et al 2019         -0.460         0   | Summer           | Norouzy et al 2017                               | 0.563         | 0.292             | 0.085         | -0.010         | 1.135          | 1.927   | 0.054   |                       |
| Summer         Roy and Bandyopadhyay 2017         -0.317         0.167         0.028         -0.445         0.011         -1.895         0.058           Summer         AL-barha and Ajaloud 2018         -0.002         0.143         0.022         -0.292         0.288         -0.013         0.990           Summer         Nachwak et al 2018         -0.021         0.082         0.007         -0.432         -0.110         -3.296         0.001         -           Summer         Prasetya and Sapwarobol 2018         0.693         0.209         0.044         -1.103         -0.282         -3.309         0.001         -           Summer         Faris et al 2019         -0.454         0.137         0.019         -0.723         -0.014         -3.003         0.001         -           Summer         Jarrar et al 2019         -0.455         0.175         0.001         -0.884         0.002         -           Summer         Aabbar et al 2019         -0.460         0.118         0.014         -0.299         -3.899         0.000         -           Summer         -0.376         0.031         0.001         -0.477         -0.182         -0.334         -11973         0.000         -           Winter <td< td=""><td>Summer</td><td>Pallavova et al 2017</td><td>-0.235</td><td>0.124</td><td>0.015</td><td>-0.478</td><td>0.203</td><td>-1.008</td><td>0.059</td><td></td></td<>  | Summer           | Pallavova et al 2017                             | -0.235        | 0.124             | 0.015         | -0.478         | 0.203          | -1.008  | 0.059   |                       |
| Summer         AL-barha and Aljaloud 2018         -0.002         0.148         0.022         0.228         0.013         0.990           Summer         Nachwak et al 2018         -0.021         0.082         0.007         -0.432         -0.110         -3.296         0.001           Summer         Parasetya and Sapwarobol 2018         -0.693         0.209         0.044         -1.03         -0.286         0.001           Summer         Faris et al 2019         -0.454         0.137         0.019         -0.723         -0.184         -3.309         0.001           Summer         Haghighi et al 2019         -0.455         0.175         0.031         -0.888         -0.201         -3.108         0.002           Summer         Jarrat et al 2019         -0.464         0.0621         -3.108         0.002   | Summer           | Roy and Bandyopadhyay 201                        | 7 -0.317      | 0.167             | 0.028         | -0.645         | 0.011          | -1.895  | 0.058   |                       |
| Summer         Nacrwar et al 2018         -0.271         0.082         0.007         -0.432         0.110         -3.296         0.001           Summer         Prase by and Sagwarobol 2018         -0.680         0.209         0.044         -1.010         -3.296         0.001         -           Summer         Faris et al 2019         -0.454         0.137         0.019         -0.723         -0.184         -3.309         0.001         -           Summer         Haghighi et al 2019         -0.454         0.137         0.019         -0.723         -0.184         -3.309         0.001         -           Summer         Haghighi et al 2019         -0.454         0.177         0.012         -1.901         0.057         -           Summer         Rahbar et al 2019         -0.460         0.118         0.047         -1.688         0.001         -           Summer         Alam et al 2019         -0.460         0.118         0.014         -0.691         -0.229         3.899         0.000         -           Summer         -0.376         0.031         0.001         -0.437         -0.182         0.033         -0.314         -1.1973         0.000         -         -           Summer <td< td=""><td>Summer</td><td>AL-barha and Aljaloud 2018</td><td>-0.002</td><td>0.148</td><td>0.022</td><td>-0.292</td><td>0.288</td><td>-0.013</td><td>0.990</td><td></td></td<>   | Summer           | AL-barha and Aljaloud 2018                       | -0.002        | 0.148             | 0.022         | -0.292         | 0.288          | -0.013  | 0.990   |                       |
| Summer         Hasers alth segmentation of 0.083         0.203         0.044         -1.103         0.0262         -3.009         0.001           Summer         Faise tal 2019         -0.454         0.137         0.019         -0.723         -0.184         -3.033         0.001           Summer         Haghighi et al 2019         -0.362         0.201         0.040         -0.776         0.012         -1.901         0.057           Summer         Jarar et al 2019         -0.545         0.175         0.031         -0.884         -0.201         -3.108         0.002           Summer         Rabar et al 2019         -0.249         0.171         0.029         -3.899         0.000  | Summer           | Nachvak et al 2018<br>Presetra and Senvershel 22 | -0.271        | 0.082             | 0.007         | -0.432         | -0.110         | -3.296  | 0.001   |                       |
| Summer         Haghighi et al 2019         -0.382         0.201         0.040         -0.776         0.12         -1.801         0.057           Summer         Jarrar et al 2019         -0.545         0.175         0.031         -0.888         -0.201         -3.108         0.002           Summer         Rahbar et al 2019         -0.269         0.171         0.029         -3.808         0.001         -           Summer         Alam et al 2019         -0.460         0.118         0.014         -0.624         0.047         1.668         0.000         -           Summer         -0.376         0.031         -0.031         -0.314         -11973         0.000         -         -           Winter         EI AH et al 1995         -0.443         0.252         0.054         0.006         -         -           Winter         Finch et al 1997         -0.473         0.182         0.033         -0.831         -0.116         -2.596         0.009         -         -           Winter         Malson istal 1998         -0.0409         0.215         0.046         0.226         -0.485         0.528         -         -         -           Winter         Bilto 1998         -0.229         0.  | Summer           | Faris et al 2019                                 | -0.454        | 0.209             | 0.044         | -0.723         | -0.282         | -3.309  | 0.001   |                       |
| Summer         Jarrar et al 2019         -0.545         0.175         0.031         -0.888         -0.201         -3.108         0.002           Summer         Rahbar et al 2019         -0.269         0.171         0.029         -0.624         0.047         -1.668         0.091           Summer         Alam et al 2019         -0.460         0.118         0.014         -0.259         -3.899         0.000           Summer         -0.376         0.031         0.001         -0.437         -0.182         0.031         -0.116         -1.1914         0.056           Winter         El Alt et al 1995         -0.483         0.252         0.064         -0.977         0.012         -1.1914         0.056           Winter         Adiouni et al 1997         -0.473         0.182         0.033         -0.311         -1.1914         0.056           Winter         Finch et al 1998         -0.074         0.153         0.024         -0.375         0.628            Winter         Bilto 1998         -0.074         0.153         0.024         -0.375         0.049            Winter         Bilto 1998         -0.074         0.158         0.062         0.011         -1.967         0.0   | Summer           | Haghighi et al 2019                              | -0.382        | 0.201             | 0.040         | -0.776         | 0.012          | -1.901  | 0.057   |                       |
| Summer         Rahbar et al 2019         -0.289         0.171         0.029         -0.524         0.047         -1.668         0.091           Summer         Alam et al 2019         -0.460         0.118         0.047         -1.668         0.091           Summer         -0.376         0.031         0.001         -0.437         -0.3899         0.000         -           Summer         -0.376         0.031         0.001         -0.437         -0.314         -11973         0.000         -           Winter         El Ab et al 1995         -0.483         0.252         0.064         -0.971         0.012         -1.914         0.056         -           Winter         Flinch et al 1998         -0.074         0.153         0.024         -0.331         -0.112         -1.904         0.057           Winter         Maislos et al 1998         -0.029         0.117         0.016         -0.529         0.0167         -           Winter         Bito 1998         -0.229         0.117         0.014         -0.517         -         -           Winter         Kaylcoglu et al 1998         -0.473         0.182         0.033         -0.819         -0.004         -         - <td< td=""><td>Summer</td><td>Jarrar et al 2019</td><td>-0.545</td><td>0.175</td><td>0.031</td><td>-0.888</td><td>-0.201</td><td>-3.108</td><td>0.002</td><td></td></td<>  | Summer           | Jarrar et al 2019                                | -0.545        | 0.175             | 0.031         | -0.888         | -0.201         | -3.108  | 0.002   |                       |
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| Winter         El Ati et al 1995         -0.483         0.252         0.064         -0.977         0.112         -1.914         0.056           Winter         Adlouni et al 1997         -0.473         0.182         0.033         -0.831         -0.116         -2.596         0.009           Winter         Flinch et al 1998         -0.049         0.215         0.042         -0.375         0.226         -0.485         0.628           Winter         Maislos et al 1998         -0.0409         0.215         0.044         -0.375         0.226         -0.485         0.628           Winter         Bilto 1998         -0.229         0.117         0.014         -0.485         0.627         0.449           Winter         Bilto 1998         -0.229         0.117         0.014         -0.485         0.009            Winter         Kaykcoglu et al 1998         -0.473         0.182         0.033         -0.011         -1.997         0.049            Winter         Kaykcoglu et al 1998         -0.473         0.182         0.033         -0.011         -2.966         0.009            Winter         Akayi et al 2000         -0.271         0.143         0.021         -0.552   | Summer           | Prath et al 2019                                 | -0.460        | 0.118             | 0.014         | -0.691         | -0.229         | -3.899  | 0.000   |                       |
| Winter         Adlouni et al 1997         -0.473         0.162         0.033         -0.831         -0.116         -2.596         0.009  | Winter           | El Ati et al 1995                                | -0.483        | 0.252             | 0.064         | -0.977         | 0.012          | -1.914  | 0.056   |                       |
| Winter         Finch et al 1998         -0.074         0.163         0.024         -0.375         0.226         -0.485         0.628           Winter         Maislos et al 1998         -0.040         0.215         0.046         -0.829         0.012         -1904         0.057           Winter         Bilto 1998         -0.229         0.117         0.014         -0.458         -0.001         -1.967         0.049           Winter         Kaykcoglu ét al 1998         -0.473         0.182         0.033         -0.311         -2.596         0.009           Winter         Akanji et al 2000         -0.271         0.143         0.021         -0.552         0.010         -1.981         0.059           Winter         -0.298         0.062         0.004         -0.477         -4.826         0.000  | Winter           | Adlouni et al 1997                               | -0.473        | 0.182             | 0.033         | -0.831         | -0.116         | -2.596  | 0.009   |                       |
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|  | winter           |  | -0.298        | 0.062             | 0.004         | -0.419         | -0.177         | -4.826  | 0.000   |                       |

**Fig. 8** Hedges' *g* values for changes in body weight for studies included in the meta-analysis according to the season during which the study was conducted. Hedges' *g* value is considered small when value = 0.2, medium = 0.5, large = 0.8.

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- <sup>571</sup> criteria applied give a more robust and reliable estimate for <sup>572</sup> the efect size. The last strength is that we performed sub-
- 573 group analyses and meta-regressions (adjustment for covari-

ates) which were not performed before. However, the current

work entailed two major limitations that should be considered: irst, the fact that the study population was mostly men;

- 576 ered: irst, the fact that the study population was mostly men;
   577 makes it diicult to generalize the results on both male and
- 577 makes it discult to generalize the results on both male and 578 female fasting people. Second, calorie intakes pre- and post-
- 578 Terrate rating people: Occorna, calorie intakce pre- and poor
- 579 RDIF were not measured in the analysis, a matter that should
- 580 be considered in any future research on Ramadan fasting and

581 body weight changes.

# 582 Conclusions

583 In conclusion, RDIF elicits a signiicant, but small, reduc-

- tion in body weight. The heterogeneity in the indings likelyrelects the variable dietary and lifestyle behaviors practiced
- 586 during the month of Ramadan, along with the variation in
- the time duration of fasting and variable climatic and geo-
- 588 graphical conditions surrounding fasting people in different
- countries. Through this work, it can also be emphasized that
- 590 weight loss is by no means universal and that weight gain

591 is possible and does happen in a significant group of people

592 who fast during Ramadan.

# 593 Supplementary 1 for combined means 594 calculation

https://www.dropbox.com/s/nds744tcpqhsc5g/Supplementary%201%20222020.docx?dl=0

# 597 Supplementary 2 for quality assessment

598 https://www.dropbox.com/s/dhol3u83kpgbgrq/Supplement 599 ary%202%20222020.doc?dl=0

# 600 Data repository link

- 601 https://www.dropbox.com/s/40t9f6w70o8lbtd/Final
- 602 %20Ramadan%20meta%20data%20472019%20%28Wei
- 603 ght%20and%20BMI%29.xlsx?dl=0

# 604 MOOSE checklist repository link

- 605 https://www.dropbox.com/s/u23n0hlk4fb457d/MOOSE
- 606 \_Checklist%2011122019%20FINAL.pdf?dl=0

Author contributions MF and HJ contributed to the conception and design of the work. MF and HJ participated in researching and col-607 lecting articles. MF and JS participated in the article reviews and data 608 extraction. HJ performed all data analyses. MF and HJ contributed 609 to drafting the manuscript, and CC contributed to critically revising 610 the manuscript and provided intellectual contributions to strengthen 611 the manuscript. All authors were involved in writing the paper and 612 approved the inal version for publication. 613 614 Funding The current work did not receive any form of inancing from any institution or funding body. 615 616 Compliance with ethical standards 617 Conflict of interest The authors have no conlicts of interest to declare. 618

Ethical approval This article does not contain any studies with619human participants performed by any of the authors620

Informed consent For this type of research, formal consent is not required. 621

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