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Published in:
Research in Sports Medicine

DOI:
[10.1080/15438627.2017.1314293](https://doi.org/10.1080/15438627.2017.1314293)

E-pub ahead of print: 16/04/2017

Document Version
Peer reviewed version

[Link to publication on the UWS Academic Portal](#)

Citation for published version (APA):

Knox, A., Sculthorpe, N., Baker, J. S., & Grace, F. (2017). Strength adaptation to squat exercise is different between Caucasian and South Asian novice exercisers. *Research in Sports Medicine*, 25(3), 373-383. <https://doi.org/10.1080/15438627.2017.1314293>

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Title

Strength Adaptation to Squat Exercise is Different Between Caucasian and South Asian Novice Exercisers.

Abstract

This study compared the progression of muscular strength (MS) adaptation between age-matched Caucasian (CAUC) and South Asian (SOU) men during 6 weeks (3 x week⁻¹) of resistance training. MS was determined pre and post intervention by 3-repetition maximum (3RM) strength tests, and data were analysed using repeated measures ANOVA. Pre-intervention upper and lower body 3RM were similar between groups and both upper and lower body 3RM increased in CAUCs ($P<0.001$) and SOUs ($P<0.001$) following resistance training. However, lower body strength adaptation (3RM) was higher in CAUCs compared with SOUs ($P=0.002$). There was a significant group x time interaction in strength progression of the squat exercise ($P=0.03$) from session 7 through to 18 (completion). The present study offers novel but provisional data that lower body strength adaptation is slower in SOU than CAUC men despite comparable adaptation to upper body strength.

Key words: Resistance Training; Racial; South Asian; Regional; Adaptation.

Introduction

Racially specific determinants of athletic performance has received a small amount of previous attention in the academic literature (Ama et al., 1990; Coetzer et al., 1993; Swift et al., 2013). In attempting to identify racial characteristics of this exercise response, elite athletic performers have been a topic of episodic public and scientific interest during the past three decades. For instance, Black East African distance runners and Black sprinters of West African and Caribbean origin have dominated endurance and sprint events in World athletics, respectively. These observations prompted investigation and subsequent identification of polymorphisms such as the α -actinin-3 R577X that demonstrate consistent associations with elite power and sprinting performances (Eynon et al., 2013). Although these endeavours have, to some degree, progressed our understanding of elite performance, the over-arching concept that muscular adaptation to exercise training may differ between racial groups, remains largely overlooked. Apart from a few small studies (Hall et al., 2010; Cubbon et al., 2010; Knox et al., 2016), South Asian (SOU) ex-patriates are largely unrepresented in the exercise science literature. SOU's originate from locations surrounding the Indian subcontinent which include countries such as India, Pakistan, Bangladesh and Sri Lanka. SOU expatriates are the largest and fastest growing ethnic minority in Western Society and account for 20% of the world's population (Celis-Morales et al., 2013). Recently, a novel cross-sectional study identified that SOU men may need to engage in 266 minutes.week⁻¹ of moderate intensity aerobic exercise to generate equivalent cardio-metabolic responses with Caucasian (CAUC) men undertaking the recommended guidelines of 150 minutes.week⁻¹ (Celis-Morales et al., 2013), suggestive of a blunted response to magnitude of exercise-training induced cardio-metabolic improvement in SOUs compared with CAUCs.

The few available exercise training intervention studies have been largely dedicated to comparison of African Americans with CAUC Americans, predominantly using clinical and

aerobic fitness outcome measures (Cook et al., 2013; Fields et al., 1997; Walts et al., 2008; Coetzer et al., 1993). Data on muscular adaptation to resistance exercise in different racial groups is lacking. Specifically, there are no studies that compare strength adaptations to resistance exercise in SOU's with other racial cohorts. Such data may provide evidence that racial background may have to be considered by exercise practitioners when programming resistance exercise.

Therefore, the aim of the present study was to compare adaptations to a 6-week resistance training programme in SOU's compared with a group of aged matched CAUCs. The short-term protocol is necessary to establish training adaptations independent of skeletal muscle hypertrophy. This would suggest that any observed adaptations were predominantly neuromuscular induced changes. Conversely, studies of muscular adaptation to resistance training have failed to find differences in the hypertrophic response between races. Walts *et al.* (2008) reported that resistance training produced equivalent hypertrophy in Caucasian and African American men and women. We hypothesised that strength adaptation, determined by upper and lower body strength tests, in response to a 6-week progressive resistance training programme, would be different in SOU's compared with a control group of age matched CAUC males.

Methods

Participants

A total of 19 CAUC and 19 SOU male volunteers provided written informed consent to participate which was approved by University of the West of Scotland ethics committee. Each subject fully understood the risks and benefits involved with participation. Prior to enrolment, subjects did not engage in any recreational or competitive sporting activities, nor did they have any prior experience of resistance training, which was confirmed by physical activity questionnaire. Fifteen CAUCs (25.5 ± 4.8 years) and 13 SOUs (25.4 ± 7.0 years) adhered to 100% of training sessions and were included in the final analysis.

Anthropometrics

Height was determined using a portable stadiometer (Leicester Height Measure, Seca, Birmingham, U.K.). Body mass was measured to the nearest 0.1 kg by commercially available scales (body composition analyser TBF-300, Tanita, Tokyo, Japan). Body mass index was calculated using the following formula; $BMI = \text{body mass (kg)} \div \text{height (m)}^2$. Total body fat percentage was calculated using bioelectrical impedance analysis (BIA) using a commercially available analyser (body composition analyser TBF-300, Tanita, Tokyo, Japan).

Muscular Strength Measures

Upper and lower body MS was measured by 3-repetition max (3RM) bench press and squats respectively, using a commercially available 20kg Olympic barbell (Pendlay Nexgen, Fort Mill, USA), Olympic weighted plates of various weight including 25kg, 20kg, 15kg, 10kg, 5kg, 2.5kg, 1.25kg (Taishan Sports Industry Group, Burlingame, USA), a standard power cage and bench press. Prior to the first attempt of the test, each participant was instructed to complete a warm-up with light resistance which would allow for 10-15 repetitions. Following a 1 minute

rest period, a load would then be applied which enabled the participant to perform 5-10 repetitions. A further rest period of 2 minutes was provided. The load was further increased which would allow for the participant to perform 4-8 repetitions. Five minutes' rest period followed which concluded the warm up procedure.

The load was increased to an estimate of 3RM judging from previous sets in the warm up. The participants were then instructed to perform a 3RM. A successful attempt was defined as all repetitions completed without any deterioration in technique, with a failed attempt defined as not achieving the required repetitions or executing poor technique. If successful, then a 5-minute rest period was provided before the load was increased. An attempt of a higher load would consequently result. If the participant failed at a higher load, then the previous attempt would be recorded as the final result. The final load in which the participant was successful at 3RM was recorded and used for analysis. These protocols were performed at baseline (PRE) and following resistance training (POST). The 3RM test was performed 3 days following the final training session. This was standardised in both groups.

Progressive Resistance Training Protocol

The resistance exercise prescription followed a linear progression model involving five compound exercises; including back squats, bench press, deadlifts, shoulder press, and lateral pull down, with additional accessory exercises. These exercises were separated into two different sessions; A and B (see Table 1). Each session was performed consecutively within the three training days per week (i.e. week 1; A, B, A, week 2; B, A, B, etc.) for the six-week duration of the study. Training days were separated by at least one rest day but no longer than two rest days.

Due to the inexperience of the participants in resistance training, it was essential that training loads were prescribed to ensure correct technique was performed. The initial intensity of

training is presented in Table 2. This ensured each participant was capable of performing each exercise safely. Each subject was required to complete three sets of ten repetitions, which has been shown to significantly increase the desired adaptations of resistance training of a novice participant (ACSM, 2009).

The criteria for training progression was the completion of the required sets and repetitions (3 x 10), without any deterioration in technique for any given exercise. Progressive loads for lower body exercises (squats and deadlifts) were standardised at 5kg increases, whereas upper body exercises (shoulder press, lateral pull down, bench press, abdominal crunches, barbell rows) progressed by 2.5kg.

Statistical Analysis

Data were analysed using SPSS version 22. Group and time interactions, main effects of time and group, simple main effects of time and group were determined by a mixed model ANOVA with repeated measures. Distribution of data were assessed by Shapiro-Wilk tests. Homogeneity of variances was assessed by Levene's test of homogeneity of variance. Homogeneity of co-variances was established by Box's test of equality covariance matrices. All assumptions were not violated ($P > 0.05$) unless otherwise stated. Where Mauchly's test of Sphericity was violated ($P < 0.05$), the Greenhouse-Geisser estimate is reported. An alpha value of $P < 0.05$ was used to indicate statistical significance. Accumulated loads during each exercise session, anthropometric and 3RM data were analysed PRE and POST intervention using a 2X2 mixed model ANOVA, which are presented as P value and effect size (η^2). Partial eta-squared values were used to estimate effect size in the presence of statistically significant differences. Bonferroni corrected independent t-tests were employed for post-hoc multiple comparisons. (Exemplar: where significant interaction was evident during the progression of squat exercise (consisting 18 sessions), statistical significance was set at $P < 0.003$, to account for multiple comparisons in sessions 7-18). Cohen (1988) guidelines, where 0.2 = small effect,

0.5 = moderate effect, and 0.8 = large effect, were used to interpret effect size between 2 groups.

Post hoc data are presented as mean difference (M), 95% CI, P value. Statistical significance

was set at $P < 0.05$. Data is presented as group mean \pm standard deviation (S.D.).

Results

PRE and POST characteristics can be found in Table 3.

Anthropometrics

No significant group \times time interactions, main effects of time or group were observed following resistance training in any measure ($P > 0.05$ for all measures).

Muscular Strength

Figure 1 shows a significant group \times time interaction in lower body strength following resistance training ($P = 0.002$, partial $\eta^2 = 0.302$). There was a significant difference at POST between groups ($P = 0.013$, partial $\eta^2 = 0.213$) with the CAUC presenting significantly greater lower body strength than the SOU group ($M = 23.462$ Kg, 95% CI: 5.278 to 41.645 Kg, $P = 0.013$). A significant simple main effect of time was observed in the CAUC group ($P < 0.001$, partial $\eta^2 = 0.910$) and the SOU group ($P < 0.001$, partial $\eta^2 = 0.809$) at POST.

There was no significant group \times time interaction between following resistance training on upper body strength ($P = 0.476$, partial $\eta^2 = 0.020$). The CAUC group ($M = 13.667$ Kg, 95% CI: 10.293 to 17.040, $P < 0.001$) and SOU group ($M = 11.923$ Kg, 95% CI: 8.3 to 15.546, $P < 0.001$) had significantly improved upper body muscle strength at POST.

1 *Resistance Exercises*

2 There was a significant group \times time interaction on the progression on squats ($P < 0.001$, partial
3 $\eta^2 = 0.282$). Figure 2 shows significant differences in squat progression between groups
4 observed from session 7 which continued until the end of the intervention ($P < 0.05$ for all time
5 points).

6 Significant increases in bench press ($M = 14.167$ Kg, 95% CI: 8.691 to 19.462 Kg, $P < 0.001$),
7 deadlifts ($M = 36.667$, 95% CI: 28.103 to 45.230 Kg, $P < 0.001$), shoulder press ($M = 13.667$,
8 95% CI: 9.552 to 17.781 Kg, $P < 0.001$) and lateral pull down ($M = 18.333$ Kg, 95% CI: 15.117
9 to 21.550 Kg, $P < 0.001$) were observed in the CAUC group at POST.

10 The SOU group experienced significant increases in bench press ($M = 13.269$ Kg, 95% CI:
11 7.387 to 19.151 Kg, $P < 0.001$), deadlifts ($M = 33.077$ Kg, 95% CI: 23.646 to 45.508 Kg, $P <$
12 0.001), shoulder press ($M = 14.231$ Kg, 95% CI: 9.811 to 18.651 Kg, $P < 0.001$) and lateral
13 pull down ($M = 18.462$ Kg, 95% CI: 15.007 to 21.916 Kg, $P < 0.001$) at POST.

14

15 **Discussion**

16

17 The aim of this study was to compare muscular strength adaptations between CAUC and SOU
18 men, during 6-weeks of resistance training. The main findings from this study are that 6-weeks
19 of progressive resistance training improves upper and lower body MS in both CAUC and SOU
20 males, however, lower body MS adaptation was slower in SOU compared with CAUC,
21 independent of changes in body composition. These data provide preliminary evidence for
22 racial differences in lower limb strength adaptation to resistance exercise between SOU and
23 CAUC men.

24 The observed findings in the current study show that the rate of adaptation between racial
25 groups is comparable in terms of upper body adaptation, but is blunted with respect to lower
26 body training adaption in SOUs. One possible explanation for the observed difference may be

27 related to a difference in neural adaptation in response to resistance training. Significant
28 increases in muscular strength are observed independent of increases in muscular hypertrophy
29 during 3-5 weeks of resistance training which is mainly accounted for by an improvement in
30 neural recruitment (Cormie et al., 2011; Folland & Williams, 2007). Furthermore, the ability
31 to generate muscular power in order to execute a movement under a mechanical load is
32 influenced by a variety of factors including; muscle fibre composition, cross-sectional area,
33 motor unit recruitment, and inter-muscular coordination. Since the lower body 3RM test
34 requires a larger degree of motor unit recruitment and inter-muscular coordination to execute
35 (compared to the upper body protocol), it may be that differences between SOU and CAUC
36 were more evident during this assessment. However, it is difficult to confirm these findings
37 given the lack of comparable data concerning training responses in SOU cohorts.

38 Previous cross-sectional research reported no differences in power outputs between African
39 Americans and CAUCs when corrected for muscle cross-sectional area (Fields et al, 1997).
40 Similarly, a longitudinal study also reported no racial differences between African Americans
41 and CAUCs in knee extensor 1RM values following 10 weeks of localised knee extensor
42 resistance training (Walts et al, 2008). Correspondingly, the higher rate of lower body adaption
43 in the present study may be due to methodological factors in addition to the racial differences
44 of the respective cohorts. The current study used whole body resistance training whereas Walts
45 and associates (2008) concentrated on the effects of training on a single muscle group.
46 Furthermore, the squat is a more complex compound movement than knee extensions,
47 requiring significantly greater coordination, and therefore may better identify differences in
48 neuromuscular adaptation. In addition, Walts et al. (2008) used a longer training programme
49 which may have combined both neuromuscular and hypertrophic adaptation.

50 There is a scarcity of data comparing strength adaptations to resistance exercise performances
51 in SOU's with other cohorts, and a similar lack of description of the progression of muscular

52 strength in SOU's. It has been shown that BMI matched African Americans produce more
53 favourable upper body strength than White Americans following 6-weeks resistance training
54 (Cook et al., 2013). The authors reported greater upper body strength in the African American
55 group at study enrolment, which may account for the differences in strength following
56 resistance training, as no significant interactions were discovered (Cook et al., 2013). This also
57 suggests that the rate of adaptation between the African Americans and White Americans were
58 similar. The comparable results between the current study and that of Cook and co-workers
59 (2013) may possibly relate to muscle group under investigation. The current investigation did
60 not identify any significant interactions between groups in upper body strength following
61 resistance training, which is in agreement with previous research (Cook et al., 2013). Taken in
62 context with the available literature, it appears that racial differences in strength adaptation to
63 resistance exercise may be confined to the lower limbs.

64 This is the first study to compare resistance training adaptations between CAUCs and SOUs. To
65 borrow from the wider literature, Misra and colleagues (2008) reported improvements in
66 insulin sensitivity in SOUs diagnosed with type 2 diabetes following 12 weeks of moderate
67 intensity resistance training. However, details of the improvements in muscular strength were
68 not reported, making it impossible to compare adaptations of muscular strength with the current
69 investigation. More recent research has reported significant time effects in SOUs participating
70 in resistance training (Hameed et al., 2012). The participants of this study performed
71 progressive resistance training 2-3 times per week for 8 weeks performing similar exercises
72 and rest periods as the current study. The authors reported significant increases in upper and
73 lower body strength, (assessed by 1-RM bench press and leg press, respectively) when
74 compared to a control group who performed static stretching for the duration of the
75 intervention. The results of the current study and that of Hameed *et al* (2012) are in agreement
76 that SOUs do adapt to progressive resistance training with increases in muscular strength.

77 However, the current study postulates a theory that the magnitude of adaptation may be
78 distinctive between racial groups.

79 It is well known that exercise is fundamental in the prevention of non-communicable diseases
80 (NCDs) such as type 2 diabetes and cardiovascular diseases. The aim of current exercise
81 guidelines is to reduce physical inactivity levels and consequent NCD risk (ACSM, 2009). This
82 has resulted in general prescription guidelines for all age groups. However, in certain
83 circumstances, more specific exercise guidelines may be required. SOUs have inferior
84 prognosis following a cardiac event compared to CAUCs for unknown reasons, and structured
85 exercise participation is a vital process in the final stages of cardiac rehabilitation programmes
86 (Astin et al., 2008). Previous research regarding differences between CAUCs and SOUs
87 response to exercise have only investigated aerobic exercise. Hall and associates (2010)
88 reported that SOUs have a reduced capacity to oxidise fat during submaximal aerobic exercise
89 compared to CAUCs of similar age, BMI and fat mass. Cubbon *et al.* (2010) also reported
90 differences to aerobic exercise between CAUCs and SOUs, as exercise induced circulating
91 progenitor cell mobilisation is reduced in SOUs compared to CAUCs. The work of Celis-
92 Morales (2013), show that SOUs may need to engage in 266 minutes of moderate intensity
93 exercise to elicit similar adaptations as CAUCs performing 150 minutes, suggesting a blunted
94 response to exercise. Although the current study has mainly studied differences in performance
95 parameters of muscular strength and not clinical markers, it agrees with the existing literature
96 that there are racially dependent responses to an exercise stimulus.

97 **Study Limitations**

98 The current study has identified differences in regional strength adaptations, which we propose
99 to be consequence of differences in neuromuscular adaptation between CAUCs and SOUs. The
100 significant increases in strength, independent of changes in body composition, provide
101 evidence of neural adaptations in both groups following the short-term protocol. However, this

102 remains speculative until verified by further electromyography (EMG) or electroneurography
103 (EMNG) study.

104 The short duration of the study may also pose as a potential limitation. The 6-week protocol
105 was sufficient to identify potential differences in neuromuscular adaptation however, a longer
106 protocol may have uncovered potential differences in hypertrophic response (Moritani &
107 deVries, 1979). Whether the SOU group could match the rate of progression following a
108 hypertrophic specific programme remains to be investigated. It was impractical and without *a*
109 *priori* rationale to biopsy muscle in order to determine muscle fibre composition in this study.
110 Differences in muscle fibre type and distribution might explain the differences in regional
111 adaptations to resistance training as previous reports have identified muscle fibre composition
112 discrepancies between racial groups.

113 In conclusion, this study offers novel but provisional data that progression of lower body
114 strength adaptation is slower in SOU and CAUC men despite comparable adaptation to upper
115 body strength. These data may be used to inform exercise prescription and adaptive training
116 programmes for SOU men.

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- 176

177 **Table legend**

178

179 **Table 1** - Exercise session design utilised during the resistance training intervention. Both
180 sessions involve the main compound exercises and accessory exercises.

181 **Table 2** - Group mean data for initial training loads. These loads were prescribed in relation to
182 participant ability and not by a percentage of strength testing. This was to emphasise correct
183 technique and ensure overall safety of the participant. Data are presented as mean \pm standard
184 deviation (SD.).

185 **Table 3**- Descriptive characteristics of Caucasian (CAUC) and South Asian (SOU)
186 participants before (PRE) and after (POST) a 6-week resistance training programme. Session
187 A and B data display the group mean of the accumulated loads lifted of each exercise within
188 each session. Individual exercise data were derived by calculating group means of the loads
189 lifted for each exercise. Data are presented as group mean \pm SD. ϕ – significant difference
190 between groups at same time point. Ω – significant difference within groups PRE to POST. *
191 - $P < 0.05$, ** - $P < 0.01$.

192

193 **Figure legends**

194 **Figure 1** - Lower body strength in Caucasians and South Asians before (PRE) and after
195 (POST) resistance training. Data are presented as group mean \pm SD). No significant
196 differences were observed at PRE ($P = 0.454$). A significant difference (*) was apparent at
197 POST between groups ($P = 0.013$).

198 **Figure 2** – Upper body strength in Caucasians and South Asians before (PRE) and following
199 resistance training (POST). Data are presented as group mean \pm SD). There were no
200 significant differences PRE ($P = 0.727$) or POST ($P = 0.938$) intervention.

201 **Figure 3** – Progression of the squat exercise in Caucasians and South Asians during 6 weeks
202 of resistance training; data presented as group mean with standard deviations (mean \pm SD). A

203 significant group \times time interaction ($P < 0.001$) identified divergence in squat progression from
204 session 7 through to session 18 (completion). Main effects of time were observed in the CAUC
205 ($P < 0.001$) and the SOU ($P < 0.001$) group.