# Influence of Isometric Contraction during Archery Training and Detraining on the Muscles and Hand Grip Strength in Sedentary Youth: A Randomized Controlled Trial

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Abstract: Team sports activities had been found to improve non-athletes physical performance. However, lack of studies reported on individual games. This present study aimed to determine whether isometric contraction of arm during archery intervention respond better to upper and lower body muscles strength and grip strength. Total thirty-four sedentary men had involved; seventeen performed 12 weeks (3x week$^{-1}$) of archery intervention (AG) and seventeen maintain as sedentary behaviour (SG). Upper and lower body muscles strength were determine at pre and post training, and detraining by isometric contraction test using hand-held dynamometer. Meanwhile, hand grip strength was assessed using JAMAR hand grip dynamometer. The data were analysed using ANOVA repeated measures. Pre intervention muscles and grip strength were similar between groups and increase significantly in archery group ($p < 0.05$). There was a significant group x time and group x intervention interaction in strength especially upper body and grip strength. Pairwise imposed that archery group improved strength between 17% and 46% compared to baseline, whilst control group varies between -4% and 6% of changes. After detraining of 12 weeks, the muscle strength of intervention group regressed. The present study offers novel but provisional data that lower body strength adaptation is lesser despite comparable adaptation to upper body strength.

## 1 INTRODUCTION

The sedentary behaviour is associated with increase central fat deposition, pericardial fat (Larsen et al. 2014) and reduce muscle activity amplitude (Pesola et al. 2016). In many cases, sedentary behaviour positively related to the prevalence of overweight and obesity (Nicholas et al. 2015). Moreover, growing of screen time (Lepp et al. 2013), prolong sitting (Larsen et al. 2014) and stationary activities are steadily increasing and limiting the physical activity (PA) to 150 minutes per week (Piercy et al. 2018). In fact, convenience to advance technology further reduces physical mobility and increase the probabilities of dramatic muscle strength deterioration (Hamer and Stamatakis 2013).

Changing lifestyle is granted to improve health and minimize sedentary behaviour duration in daily living (Barwais and Cuddihy 2015). Considering these facts, few studies explored sport interventions to promote PA and muscle function in sedentary population. Fenton et al (2016) found sport activities responsible to lessen the engagement time to sedentary behaviour and improve general health (Zolkafi et al. 2019). Furthermore, by improving the exercise intensity and duration, the muscle quality, postural balance and activity adaptation are also obtained benefits (Sundstrup et al. 2010; Zolkafi et al. 2018).

Those with sedentary lifestyle often reported to have high body weight and high adiposity. They were reported to have lower self-esteem (Nihill, Lubans, and Plotnikoff 2013), thus unmotivated to perform any PA. Therefore, selection of suitable sport nature is important in order to encourage sedentary people to sustain their new routine. Archery is one of the stationary game which requires physical strength, body stability and focus. The isometric contraction of



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muscle to overcome bowstring tension (Johnson 2015) which furthermore strengthen muscles.

However, lack of studies exist exploring the development of muscle strength in sedentary people following an archery sport. These data are essential because sedentary people are vulnerable to health-related matters (Larsen et al. 2015) and higher risk of exercise withdrawal. Quitting from training reverses the benefits of sport involvement (Zech et al. 2012). Data on the effects of archery training and also detraining might assist sedentary people to improve health status and minimize risk of withdrawal.

In the present study, sedentary men underwent a 12-weeks archery training and detrained for another 12-weeks. Strength of six major muscles in upper and lower body, and hand grip were measured. We hypothesized that the archery training would increase muscle strength and reverse the effect following detraining period.

# 2 METHODOLOGY

Study participants included 34 healthy inactive youth men who obtained from preliminary study (n=208) using simple random sampling. The sedentary status (<150 minutes per week of MVPA) was confirmed by SQUASH questionnaire (Admiraal et al. 2011). Subjects were randomly assigned to archery, AG ($n$ =17, age = 21.4 ± 1.3 years) and sedentary group, SG ($n$ = 17, age = 22.3 ± 1.6 years). The inclusion criteria were those age 18 to 30 years, practice sedentary lifestyle and free from any chronic and terminal diseases. We exclude those who are consuming any supplements known to boost energy or alter muscle strength, having any kind of body fractures, muscle injury, carpal tunnel syndrome or cardiovascular diseases. Those assigned to AG was required to play archery 3 days per week for 12 weeks. The SG was instructed to maintain their lifestyle.

Participants were cautiously informed details of experiment protocol and possible risks related to the study prior to obtain informed consent. No dropped out of participants were recorded. Ethic approval obtained from the Research Ethic Committee of Universiti Sains Islam Malaysia (USIM/REC/0416-3) and was performed in accordance with the Declaration of Helsinki.

## 2.1 Experimental Design

Participants were explained about the procedure of muscle and hand grip strength (HGS) assessment prior to the study. Both groups were assessed three times; Week 0 (baseline), Week 12 (post-intervention) and Week 24 (detraining). They were prohibited from consume caffeine at least 24 hours before assessment because it's potential to influence strength and endurance of muscles (Warren et al. 2010). The assessment was not performed immediately after archery training.

## 2.2 Muscle Strength Assessment

Six muscles were assessed involving upper and lower body (elbow flexors, elbow extensors, shoulder abductors, knee flexors, knee extensors and hip abductors). Subjects were instructed to be in fully supported position according to specific assessed muscles (Table 1). The muscle strength was measured using Commander$^{TM}$ Muscle Testing Dynamometer. This simple device contains a small internal load cell which is capable to measure the muscular force. The unit used for muscle strength was in pound (lbf). The greatest score of muscle strength was the final score amongst three readings. The muscle strength score for both right and left muscles were recorded as mean.

## 2.3 Hand-grip Strength

Hand grip strength (HGS) measurement was done using Jamar Hand Dynamometer (Patterson Medical, Serial No: 1311184; Canada) for both sides based on American Society of Hand Therapist (ASHT) recommendation (El-Sais and Mohammad 2014). The test was conducted in sitting position. The elbow was 90º flexed and shoulder was abducted (Lam et al. 2016). The hand grip dynamometer was set to the second handle position for every subject. The subjects were instructed to squeeze the handle maximally for three seconds. The tests were conducted three times with one minute interval between each test. The result of the HGS was recorded in kilogram to the nearest one decimal point. The mean of the three measurements for each hand were regarded as the HGS.

## 2.4 Training Protocol

Each subjects in AG group were provided with a diary and required to record the dates of training which was conducted by a qualified archery coach. On top of that, AG subjects were given an introductory session included basic archery techniques, rules and regulations to be obliged along the timeline. The trial session introduced the methods using a naked bow because no additional devices were equipped on the bow. The type of arrow used was carbon arrow.

The subjects held the bow using left hand (straight the elbow and shoulder abduct at 90º) and draw the string using another hand. The target butt was located at left shoulder side (in 10 meters distance) and the right shoulder was on one line with left shoulder. The anterior body was not facing to the target butt. The feet were planted in shoulder width distance. The left foot faced butt and right foot in same direction with the body. A mid-point of string was put in between an arrow nock. By using three fingers (index, middle and ring finger) as a hook, the string drew (35 – 40 lbs.) until reach to cheek. The subjects to hold about 5 seconds for aiming purpose. Then, subjects released the arrow as soon as they satisfied with the aim.

Based on the regime, subjects were attended three sessions weekly for 12 weeks (6 shots x 7 sets each session; total arrow shots was 1512 arrows). The detraining phase was started from week 12 to week 24. The subjects were advised to withdraw from archery training and any other PA to avoid any confounding results.

### 2.5 Statistical Analyses

Statistical analyses were performed using a two factor general linear model. The statistical significance was accepted at the $p$<0.05. Group x time interaction, time and group main effects were determined by ANOVA repeated measures. The data distribution were assessed by Shapiro-Wilk meanwhile homogeneity of variance were evaluated by Levene's test. All assumptions were not violated unless statistically stated. Greenhouse-Geisser estimate is reported when Mauchly's test of Sphericity was violated. The alpha value ($p$ < 0.05) was set to indicate the significant difference. The muscles strength score during each of sessions were analysed using a 3 x 2 mixed model ANOVA which presented as $p$ value and effect size.

## 3 RESULTS

Baseline characteristics showed both groups were similar. No significant different was obtained for all variables (Table 2).

For muscle strength, the results from ANOVA repeated measure indicated a significant time effect (p < 0.05) for all tested muscles. Similarly, upper body muscles and knee flexors were obtained significant intervention effects. Based on the findings, following 12 weeks of archery intervention, all muscles were reported increased in strength but not for SG. As expected following withdrawal of archery training, there muscle strength were declined.

Similarly for HGS, results found a significant main effect for time (p<0.05) for both right and left hand. However, only left hand was reported obtained significant difference on the intervention effect. General results suggested that archery training improved HGS following 12 weeks intervention for both hand.

## 4 DISCUSSION

Based on our knowledge, this is the first study which exploring the component of isometric muscle in archery as an intervention to combat effects of sedentary on muscles strength. These results suggest big group of muscles were comfortably adapted to the component of isometric contraction in archery training. On observation, the muscle strength were remained significantly elevated at post intervention compared to baseline. Similarly, the post-intervention and detraining also showed declination in strength for upper and lower body and hand grip. Interestingly, the muscle strength following 12 weeks of detraining were still higher than baseline.

Several experimental studies had reported improvement in overall performance following football involvement among sedentary (Cvetkovic et al. 2018). However, lack of literature engaged with archery as an intervention for sedentary population. The available sources reported that there are activation of muscles especially forearm (Ertan 2009), and shoulder complex (Shinohara and Urabe 2017). Therefore, the improvement of hand grip and upper body muscle strength following structured archery training were due to consistent activation of muscles every time archers performed arrow shooting. Since all of the participants were non-archers, the utilization of muscles are higher compared to elite and junior archers (Ertan et al. 2003). Furthermore, implementation of holding time during aiming phase help the muscle strength developed even more. During these phase, the stability of glenohumeral joint and scapular are required (Lin et al. 2010). With the training, the tremor symptom which presence due to muscle weakness was gradually reduced and disappeared.

The frequency of string drawing is mimic to other load in resistance training regiments. This further boost the factor of strength development in the targeted muscles. Despite the loads used was 35 to 40 pounds through the string weight, higher repetition provides development of muscles strength especially to untrained adolescent (Assunção et al. 2016). Moreover, combination blood flow restriction and low resistance exercise acted as hypertrophy stimuli (Wackerhage et al. 2019). This is crucial where the low-load in training increases the higher muscle fibre type 1 compared to high-load training (Grgic and Schoenfeld 2018). Isometric muscle contraction causes both agonist and antagonist muscles to contract concentrically at the same time which causes the localize blood vessels are pinched thus slower down the blood flow. Interestingly, during archery training, this isometric muscle contraction was repeatedly performed especially during string drawing and aiming phases plus holding time.

Apart of significant improvement on upper body, lower body muscles also showed significant improvement following 12 weeks of archery intervention. The improvement was recorded with no special intervention provided to lower body muscles. This novel findings are remarkable especially to the stationary sport activity. Explorative experiment found that high activation of quadriceps and calf muscles reported during contralateral isometric contraction of shoulder flexion and abduction (Lee, Park, and Lee 2014). This findings reflected the influenced of upper body isometric contraction and lower body muscles during archery activity.

Additionally, static standing also responsible to further recruits lower body muscles to be more stable in order to stand steadily and minimize body postural sway (Handrigan et al. 2012). This is an important component to assist in shooting accuracy especially in long period. Archers normally facing experience of an antero-posterior (AP) and medio-lateral (ML) body sway (Simsek et al. 2018) while play. There are two major factors compromise postural stability and increase the body sway phenomenon; muscles weakness and reduce joint proprioception (Barbieri et al. 2019; Hwang et al. 2016). Both problematic causes are frequently found in elderly (Hassan, Mockett, and Doherty 2001) but also could happened to younger population following lack of physical activities. During training, archers spend higher duration in standing which unconsciously recruits the lower body muscles to gain the strength and develop muscles endurance.

Based on the results, hamstrings muscles showed significant improvement after 12 weeks of training. In archery, body sway has crucial influence in performance in which the lower level archers had greater sway, AP and ML ground reaction force (Simsek et al. 2018). Due to bow weight, AP sway was expected to be dominant compared to other direction. For anterior posture sway, hamstring activity was found greatest during upright stance (Prior et al. 2014). Therefore, it contributed to the great improvement of hamstring strength following specific body posture during shooting activity.

Withdrawal from training caused upper and lower body and HGS dramatically deteriorated. It considered a normal phenomenon after restricting or completely quits from the previous PA. The investigation of detraining is important to explore how much the muscles were affected from the archery training. There is an evidence of reduction in strength following cessation from strength training further affect the ability of muscle to perform contraction as similar as during training (Khademi et al. 2015) although no significant changes were reported in muscle thickness, lean mass and muscle contractility (Psilander et al. 2019; Shima et al. 2002; Zech et al. 2012). Based on the findings, hip flexor and shoulder abductor muscles were the biggest loss of strength following 12 weeks of detraining at 24% and 19%. Although reduction reported the muscles strength still reported had greater scores compared to baseline. The event suggested the good carry effect of archery training on the muscles after activity cessation.

According to findings, twelve weeks archery training is suggested to improve muscles strength to both upper and lower body, and HGS. Withdrawal from the training risks for reduction of strength especially to the upper body muscles.

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# APPENDIX

Table 1: Subjects' position and HHD placement for muscle strength assessment.

| Muscle | Body position | Joint position | HHD placement | Movement |
|---|---|---|---|---|
| Elbow flexors (Douma et al. 2014) | Supine lying | Elbow bend at 90º | Proximal to styloid process of radius | Bend the elbow |
| Elbow extensors (Douma et al. 2014) | Supine lying | Elbow bend at 90º | Proximal to head of ulnar | Straighten the elbow |
| Shoulder abductors (Douma et al. 2014) | Sitting | Shoulder abduct at 90º | Proximal to lateral epicondyle of humerus | Abduct the shoulder |
| Knee flexors (Tedla et al. 2010) | Supine lying | Knee bend at 90º | Below to the tendo-achilles | Bending the knee |
| Knee extensors (Douma et al. 2014) | High sitting | Knee bend at 90º | Proximal to talus | Mimic to kicking a ball |
| Hip abductors (Moradi et al. 2014) | Side lying | Hip abduct at 45º | Proximal to lateral condyle of femur | Mimic to side kicking |

Table 2: Physical characteristic of participants according to groups.

| Characteristic | Groups | | *p* value |
|---|---|---|---|
| | ATG (n =17) | CG (n=17) | |
| Age (years) | 21.35±1.32 | 22.29±1.61 | 0.072 |
| Height (cm) | 165.66±5.16 | 167.19±5.80 | 0.422 |
| Weight (kg) | 81.07±16.29 | 86.30±22.01 | 0.437 |
| BMI (kg/m$^2$) | 29.49±5.39 | 30.75±6.84 | 0.553 |
| PBF (%) | 33.39±9,19 | 33.84±9.82 | 0.892 |
| SMM (kg) | 29.68±4.53 | 31.09±4.25 | 0.356 |
| TBW (L) | 38.71±5.6 | 40.45±5.18 | 0.355 |
| BFM (kg) | 27.95±12.40 | 31.07±15.78 | 0.526 |

$p > 0.05$; No significant difference using Independent T-Test
BMI = Body Mass Index; PBF = Body Fat Percentage; SMM = Skeletal Muscle Mass; TBW = Total Body Water; BFM = Body Fat Mass.

Table 3: Muscles strength and hand grip strength before, after training and detraining in sedentary youth, n=34.

| Variables | Intervention | | After | Time effect | Group effect | Intervention |
|---|---|---|---|---|---|---|
| | Baseline (lbf) | Post (lbf) | Detraining (lbf) | (Partial ETA) | (Partial ETA) | effect (Partial ETA) |
| Elbow Flexors | | | | | | |
| AG | 33.60±5.73 | 49.06±10.30 | 41.71±6.33 | 0.001 (0.352) *** | 0.010 (0.191) *** | 0.001 (0.418) *** |
| SG | 35.11±9.11 | 34.03±8.83 | 34.59±8.96 | | | |
| Elbow Extensors | | | | | | |
| AG | 29.91±5.40 | 41.18±7.58 | 34.70±6.83 | 0.001 (0.301) *** | 0.051 (0.114) | 0.001 (0.308) *** |
| SG | 30.45±6.75 | 30.52±7.57 | 32.12±8.09 | | | |
| Shoulder | | | | | | |
| Abductors | 27.90±7.35 | 36.60±8.88 | 30.67±6.62 | 0.006 (0.168) ** | 0.908 (0.001) | 0.010 (0.148) * |
| AG | 32.39±4.32 | 32.20±5.78 | 29.99±6.28 | | | |
| SG | | | | | | |
| Knee flexors | | | | | | |
| AG | 28.91±3.72 | 40.31±6.90 | 32.43±4.44 | 0.001 (0.450) *** | 0.001 (0.315) *** | 0.001 (0.288) *** |
| SG | 27.94±5.14 | 29.83±5.22 | 28.09±4.71 | | | |
| Knee extensors | | | | | | |
| AG | 39.44±10.03 | 46.00±9.15 | 48.31±15.12 | 0.018 (0.117) * | 0.257 (0.040) | 0.085(0.074) |
| SG | 40.38±9.09 | 42.42±8.42 | 41.08±8.39 | | | |
| Hip abductors | | | | | | |
| AG | 35.67±10.95 | 45.91±14.23 | 39.15±7.92 | 0.012 (0.147) * | 0.880 (0.001) | 0.178 (0.054) |
| SG | 40.52±7.82 | 42.98±7.80 | 38.28±8.31 | | | |
| Right Handgrip | | | | | | |
| AG | 73.80±13.80 | 91.08±21.06 | 82.79±14.29 | 0.006 (0.147) * | 0.727 (0.004) | 0.097 (0.070) |
| SG | 82.01±11.82 | 85.49±17.00 | 84.32±13.71 | | | |
| Left Handgrip | | | | | | |
| AG | 66.29±14.09 | 85.02±20.12 | 77.04±12.42 | 0.033 (0.008) * | 0.606 (0.008) | 0.002 (0.178) *** |
| SG | 77.85±9.89 | 74.91±12.49 | 68.95±24.79 | | | |

Values are Mean ± standard deviation (SD)
* $p < 0.05$ - Significant difference using ANOVA repeated measures for both groups
** $p < 0.005$ - Significant difference using ANOVA repeated measures for both groups
*** $p < 0.001$ - Significant difference using ANOVA repeated measures for both groups

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