12-Month changes of Muscle Strength, Body Composition and Physical Activity in adults with Dystrophinopathies

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Abstract

Purpose. Muscular dystrophy (MD) is an umbrella term for muscle wasting conditions, for which longitudinal changes in function and body composition are well established in children with Duchenne (DMD), however changes in adults with DMD and Beckers (BMD), respectively, remain poorly reported. This study aims to assess 12-month changes in lower-limb strength, muscle size, body composition and physical activity in adults with Muscular Dystrophy (MD).

Methods. Adult males with Duchenne MD (DMD; N = 15) and Beckers MD (BMD; N = 12) were assessed at baseline and 12-months for body composition (Body fat and lean body mass (LBM)), Isometric maximal voluntary contraction (Knee-Extension (KEMVC) and Plantar-Flexion (PFMVC)) and physical activity (tri-axial accelerometry).

Results. 12-month change in strength was found as -19% (PFMVC) and -14% (KEMVC) in DMD. 12-month change in strength in BMD, although non-significant, was explained by physical activity (R^2=.532-.585). Changes in LBM (DMD) and body fat (BMD) were both masked by non-significant changes in body mass.

Discussion. 12-month changes in adults with DMD appear consistent with paediatric populations. Physical activity appears important for muscle function maintenance. Specific monitoring of body composition, and potential co-morbidities, within adults with MD is highlighted.

Keywords: Beckers; Duchenne; Dystrophy; Natural History; Physical Activity; Strength.

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Main Text:

Introduction

Duchenne (DMD) and Beckers (BMD) Muscular Dystrophy (MD) are two genetic conditions resulting in progressive muscle weakness and declining muscle mass [1]. Unlike many other forms of MD, which affect a variety of different proteins associated with the sarcolemma [2], DMD and BMD are unique in that they are both affected by impairment of the same protein, named Dystrophin [3, 4]. DMD results from an absent or non-functioning dystrophin protein, therefore is more progressive, with loss of ambulation by the age of 12 [5, 6]. BMD in comparison is caused by a partially functioning dystrophin protein, therefore a slower and more variable form of MD, with the loss of ambulation in adulthood [5, 6]. Despite the well acknowledged genetic understanding of these conditions [3, 4, 7-9], and a breadth of research assessing health and function in children with DMD [10-17], basic understanding of the progression of these conditions and impact on function and health measures remains minimal in adult populations [18].

Lower limb muscle strength has historically been a key outcome measure reported in MD [19-25], with assessment using direct measures (either objectively using dynamometers or through subjective assessments such as manual muscle testing (MMT)) or indirect measures, such as

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sit-to-stand or 10m walk time [19, 22, 26-29]. Longitudinal strength change in BMD has only been described through MMT assessment of knee extension strength (KEMVC) however, showing annual declines of 1.2% [28]. More recently, the current authors demonstrated that in adults with MD, variance in KEMVC and functional measures could be explained by accelerometer determined physical activity (PA)[19]. It is therefore important to understand the rate of strength decline in adults with BMD, but also to assess the impact of PA on strength.

Cross-sectional and natural history studies by comparison are more common within children with DMD [20, 21, 23, 30, 31]. Indeed, muscle weakness is typically identified during childhood in DMD, with impaired gait an early indicator of DMD [32, 33]. Subjective methods of MMT or Medical research council scales (MRC%) have reported annual declines of KEMVC as 4-5% and 1.2-2% in ambulant (5-13 years) and non-ambulant (13-24 years) children with DMD, respectively [27, 34, 35]. Objective measures such as dynamometers however have identified, annual declines of KEMVC as 15% in children with DMD (8-12 years) [36]. Despite lower limb muscle strength having limited clinical relevance in adults with DMD, it remains essential that a comprehensive understanding of the progression of DMD in this older, unreported age group is developed, in order to develop a life-long understanding of condition progression, provide comparative norms using relevant and accessible methods, as well as to provide comparisons for future longitudinal assessments of steroid or gene therapy studies which may be relevant to this group [18, 37].

Strength and function have been associated with Lean Body Mass (LBM) in children with DMD [38, 39]. While pseudohypertrophy (increased muscle size without relative increase in strength) of the calves is well documented in children and adolescents with DMD [31, 40, 41], recent research suggests it may not persist in adults with DMD however [19, 42]. Furthermore, the pre-disposition of impaired muscular, respiratory and cardiac systems to ill health can be placed under further pressure by increased sedentary behaviour [19], resulting in greater fat

106 mass, which has previously been cited as a common co-morbidity in adults with MD [43, 44],

107 and reported as higher in non-ambulant than ambulant adults with BMD [45]. Continual

108 assessment, and understanding, of body composition changes of both lean and fat mass is

109 essential, for not only their implications on function, but also the much broader impacts on

110 health and wellbeing [13, 46].

111 This study aims to: 1) Quantify changes, from a one year follow up, in body composition,

112 muscle strength, muscle size and physical activity levels in adults with DMD and BMD; and

113 2) Identify the impact of changes in physical activity on body composition and muscle strength.

114 The authors hypothesise that declines will be greater in DMD than BMD, although still evident

115 in both conditions, for lower limb strength, muscle size and LBM. In addition, PA may account

116 for some of the variance in lower limb strength change in BMD, but not DMD.

117 **Materials and Methods**

118 This study comprised of adult male volunteers with DMD (n= 15) and BMD (n= 12). All

119 participants were recruited from, and tested at, The Neuromuscular Centre (Winsford, UK). No

120 participants were habitually taking part in a structured training programme, however all were

121 receiving weekly, bi-weekly or monthly physiotherapy treatment, consisting of passive

122 stretching, along with access to low intensity cardiovascular exercise equipment (monthly

123 frequency of physiotherapy for DMD = 4 (1-4), BMD = 2 (1-2) expressed as Median (range**).**

124 Ethical approval was obtained through the Manchester Metropolitan University Ethics

125 Committee, and all participants signed informed consent forms prior to participation. All

126 procedures complied with the latest edition of the World Medical Association Declaration of

127 Helsinki [47].

128 All method protocols, data presentation and reliability, have been reported previously [19],

129 where they can be read in full. A brief overview of each method has been presented below.

Procedures

All participants undertook Baseline and 12 ±1 month follow up testing. Testing involved functional and morphological tests, which was followed by a 7-day PA assessment, using wrist-worn three-dimensional accelerometers, worn 24 hours a day. The same equipment was used for all participants and due to the high level of contractures present in some participants; all participants were assessed in a seated position to ensure consistency.

Sample Size

In order to determine the sample size required to provide a representative sample for 12 month changes in adult populations of DMD, statistical *a Priori* power calculations were performed using G*Power 3.1.9.2 software (Franz Faul, Universitat Kiel, Germany). For this calculation, alpha was set a 0.05 and beta at 0.80. The DMD sample size was calculated to show a 10% change in muscle strength score consistent with the natural history group previously reported by Mendell et al. [34]. This method calculated an adequate adult DMD sample size of n = 15. For BMD, due to the lack of extant data for *a Priori* calculation to be performed, it was deemed that the power calculation for BMD participants in clinical trials (n = 15) by Bello et al. [7] was appropriate.

Anthropometry

All participants were weighed in a digital seated scales system (6875, Detecto, Webb City, Mo, USA). Slings, shoes, splints etc. were weighed separately and subtracted from the gross weight. All participants' height was calculated as point-to-point of arm span (index finger, elbow, shoulder and across midline) to replicate the method used on non-ambulatory participants [45, 48].

Body Composition

Body composition measures of body fat and LBM were measured using Bioelectrical Impedance (BIA) in a fasted state following a 12 hour fast, with adhesive electrodes placed on

155   the right hand and foot. BIA has been promoted as a measure for change in fat and LBM over

156   time in a dystrophic population [16].

157   Lean Body Mass was determined by the following equation:

158     $$LBM\ (Kg) = Body\ Mass\ (Kg) - Fat\ Mass\ (Kg)$$

159   Body Mass Index (BMI) was calculated using the following equation [49]:

160     $$BMI\ (\frac{Kg}{m^2}) = Body\ Mass\ (Kg) \div Height^2\ (m^2)$$

161   *Muscle Strength*

162   Due to the high levels of contractures present in adults with DMD, strength testing protocols

163   were designed to be completed on the most mechanically limited participants, and replicated

164   on all others. Therefore, isometric plantar flexion maximal voluntary contraction (PFMVC)

165   and KEMVC force was recorded using a load cell, with all participants in a seated position

166   replicative of quantitative muscle testing [31]. The load cell was calibrated using a known load

167   of 500g-5kg, in 500g increments, prior to every strength testing session. MVC measures all

168   took place with the participant seated, with hip and knee angles maintained at 90°, for which

169   non-ambulant participants remained in their manual/power wheelchair. For KEMVC, a strap

170   was tightly fastened around the participant's ankle, and attached perpendicularly to the load

171   cell, which was fastened to a weighted support bar. For PFMVC the participants foot was

172   attached to a footplate, with the load cell attached underneath. PFMVC measures were taken

173   from 0° (neutral position), or as close to neutral as possible due to equinus deformity evident

174   in DMD [50]. For PFMVC the practitioner provided the resistive force to ensure an isometric

175   contraction, and all measures of force were normalised for gravity. Three trials were performed

176   for PFMVC and KEMVC respectively, with extended breaks of 1 minute between trials due to

177   the increased fatigue associated with MD [51]. Force (N) was converted to torque (N·m) by

178   multiplying the force measurement by the moment arm from the axis of rotation (knee or ankle)

179   to the point of force measurement (the strap height on the shin, or ball of the foot). PFMVC

180   and KEMVC measures have been presented as torque (N.m).

181   This method has been shown to be highly reliable for both PFMVC and KEMVC in adults with

182   DMD (Within Day ICC: 0.98 and 0.99; Between Day ICC: 0.98 and 0.99) and BMD (Within

183   Day ICC: 0.91 and 0.99; Between Day ICC: 0.83 and 0.99) [19].

184   *Muscle Size Assessment*

185   Gastrocnemius Medialis (GM) anatomical cross sectional area (ACSA) was measured using

186   transverse ultrasound scans (7.5-MHz linear array probe) at 50% of muscle length, consistent

187   with the muscle length at which the largest ACSA occurs [52]. Echoabsorptive tape (Transpore,

188   3M, USA) was used to project shadows on the ultrasound image during recording to provide a

189   positional reference. From which still images were captured then recreated into a single image

190   offline (Graphic Image Manipulation Program, GIMP Development) using the shadows from

191   echoabsorptive tape, muscle markers and aponeurosis of the muscle. The ACSA was then

192   measured using digitising software (ImageJ 1.45, National Institute of Health, USA). Further

193   details can be found in our previous reports of GM ACSA in MD [42, 45]. This method of

194   ACSA assessment has been reported previously as reliable (0.998) and valid (0.999) in

195   comparison to Magnetic Resonance Imaging (MRI) [53].

196   It is important to note that this method measures the area within the fascia of the muscle

197   boundaries only, it cannot differentiate muscle or fibrous tissue (more commonly recognised

198   as fat fraction) as seen in MRI [31, 54-56]. Therefore, GM ACSA is a method of assessing

199   psuedohypertrophy only, and not muscle quality or contractile capacity.

10m Walk Time

Nine ambulant BMD participants performed a 10m walk test, one participant however lost ambulation during the one year follow up period, therefore data is presented of the 8 participants that completed both the Baseline and 12 months testing. The 10m walk was performed on an even surface, and is a common measure of function within neuromuscular conditions [36, 57]. All participants started in a standing position and were instructed to walk as quickly and safely as they could, with the time recorded from the verbal instruction of "Go" from the practitioner, to the point of crossing the finish line. Walking aids were permitted if required. Participants 10m walk time were recorded as early in the day as possible to limit the effect of fatigue, with the 12-month measure taking place at the same time.

Physical Activity

Daily PA was monitored over a consecutive 7-day period using a wrist-worn tri-axial accelerometer (GENEActiv, Kimbolton, Cambs, United Kingdom). Monitors were initiated to collect data at 100 Hz, worn for 24 hours a day on the preferred wrist of participants and worn continuously for 7 days [58]. Upon completion of 7-day monitoring, data is downloaded into .bin files, converted to 60s epoch .csv files using the GENEActiv PC Software (Version 2.1). 60s epoch data files were then entered into an open source Excel macro (v2, Activinsights Ltd.) [59]. GENEActiv monitors have shown high validity for the measurement of both PA and SB (Pearon's r = 0.79-0.98) [59, 60]. PA is presented as a percentage of time spent sedentary (SB%) or total time spent physically active (TPA^{mins})[19].

Functional Status

All participants functional status was assessed by an experienced neuromuscular physiotherapist using the Swinyard Severity Classification scale [61]. The Swinyard Severity Classification grades function and ability to carry out activities of daily living from Stage 1 "mild abnormalities in gait, able to climb stairs without assistance", to Stage 8 "Unable to sit

225 without considerable support, requires maximal assistance for activities of daily living". The

226 Swinyard Severity Scale has been used extensively in MD research [62-64], and shown to be

227 highly correlated with fraction of lower limb muscle mass in DMD [54].

228 *Statistical Analyses*

229 All analyses were performed using IBM SPSS Statistics v21 software with a critical level of

230 statistical significance set at 5% and all data presented as mean (SD), except for Functional

231 Status which is presented as Median (Range). We have previously published between group

232 differences for baseline measures [19], with the present study interested in differences from

233 baseline-12 months, therefore statistical analysis has been performed on baseline to 12 month

234 changes only (within group), with baseline values presented for clarity. Test for parametricity

235 were performed upon all variables, for repeated measures in DMD, body mass, height, BMI,

236 Lean Mass and PFMVC were parametric, and all other variables were non-parametric. For

237 BMD height, body fat, Lean Mass, GM ACSA, PFMVC, SB% and TPA^{mins} were parametric,

238 all other variables were non-parametric. Respiratory, Gastrostomy and Ambulatory statuses are

239 presented as a characteristic and no statistical analysis was performed on it.

240 For repeated measures, Paired T-tests and Wilcoxon signed rank tests, for parametric and non-

241 parametric respectively, were used to identify changes, with a Bonferroni correction. Where

242 relevant, comparisons are presented with P values, the relative change (%) from baseline and

243 95% Confidence Intervals.

244 Stepwise Multiple Linear Regression was used to identify the best predictors of PFMVC

245 change from GM ACSA Change, LBM Change and Baseline PFMVC. Linear, Quadratic and

246 Cubic regressions are used to best model changes in body composition and muscle strength in

247 relation to age and changes in TPA^{mins}, with the best fit model presented.

248 **Results**

249 *12 Month Changes*

250 *DMD*

251 Compared to baseline, 12 month PFMVC and KEMVC decreased in DMD by 19% (P=0.002)

252 and 14% (P=0.003), respectively. Compared to baseline, 12 month LBM and GM ACSA

253 decreased by 5% (P=0.002) and 8% (P=0.012) respectively, in DMD. No other differences

254 were identified between baseline and 12 months for measures of anthropometrics, body

255 composition or muscle size for DMD (table 1, P>0.05).

256   **[Table 1 Here]**

257 *BMD*

258 There was no difference in KEMVC or PFMVC compared to baseline in BMD (P>0.05).

259 Compared to baseline 10m walk time increased in ambulant BMD by 13% (P=0.005). No other

260 differences were identified between baseline and 12 months for any other measures (table 1).

261 Compared to baseline there was no significant change in GM ACSA or LBM in BMD (P>0.05).

262 In BMD, compared to baseline, Body Fat increased by 4% (P=0.009) after 12 months. One

263 BMD participant lost ambulation between baseline and 12 months. No other differences were

264 identified between baseline and 12 months for measures of anthropometric, body composition

265 or muscle size for BMD (table 2, P>0.05).

266   **[Table 2 Here]**

267 *Regressions*

268 Stepwise Multiple Linear Regression identified a model containing Baseline PFMVC, GM

269 ACSA change and LBM Change best predicted PFMVC Change in DMD (R^2=0.582,

270 P=0.019).

271 No relationship was identified for DMD using any regression model for age or TPA^{mins} change

272 with change in PFMVC, KEMVC, LBM or body fat (P>0.05). No relationships were identified

273 for either DMD or BMD using any regression model for age with change in PFMVC, KEMVC,

274 LBM or body fat, or TPA^{mins} change with change in LBM or body fat (P>0.05).

275 In BMD quadratic polynomial regressions best identified relationships for TPA^{mins} change with

276 PFMVC change (R^2=.585, P=0.019, figure 1A) and KEMVC change (R^2=0.532, P=0.033,

277 figure 1B). No relationships were identified in DMD using any regression model for TPA^{mins}

278 PFMVC change or KEMVC change (P>0.05).

279 **[Figure 1 Here]**

280 **Discussion**
281 The present study reports 12 month changes in lower limb muscle strength, muscle size and

282 body composition in adults with BMD and DMD. 12-month changes in lower limb function

283 have been identified using objective measures of muscle strength in adults with DMD and

284 BMD. After 12 months, LBM, GM ACSA, PFMVC and KEMVC decreased in DMD, whereas

285 in BMD there was no change in any measure, other than body fat which increased. Although

286 there was no significant decrease in strength within BMD, the variance in the 12-month change

287 of PFMVC and KEMVC was partially attributable to the variance in physical activity change

288 over the same period.

289 The 14% decline in KEMVC in adults with DMD in the present study is consistent with the

290 15% decline previously reported over a similar timeframe in children with DMD [36]. These

291 declines in KEMVC are in contrast to the 2% and 1.2% declines reported in non-ambulant

292 children and adolescents with DMD, respectively [35, 36]. This discrepancy can be attributed

293 to the greater sensitivity of the methods used in the present study to quantify changes in

294 KEMVC, rather than subjective measures of MMT or MRC% [65, 66]. In adults with BMD

295 we observed no significant change in KEMVC or PFMVC, likely due to greater variance

296 associated with the condition, however the quantified declines of 14% KEMVC and 7%

297 PFMVC remain noteworthy.

298 The increase in body fat in BMD (+4%) in the present study appears consistent with our

299 previous research in which excess weight gain was identified as an issue in BMD, especially

300 in non-ambulant individuals [45]. The relative increase in body fat in BMD compared to DMD

301 may be due to the fact that BMD maintain a greater level of function and physical independence

302 [67], compared to DMD [48] who require assistance in the preparation and consumption of

303 food. Monitoring and management of food intake may be easier and more structured in DMD

304 [68], particularly given 4/15 participants in the current study consumed via PEG. The stable

305 body mass in both DMD and BMD did however mask changes in body composition, with

306 decreased LBM in DMD and increased body fat in BMD. Therefore reaffirming the need for

307 body composition monitoring in these conditions [16].

308 Adults with BMD that maintained or increased PA levels showed a relative increase or

309 maintenance of muscle strength compared to those that decreased PA levels. Increased PA has

310 previously been attributed to decelerating fatty infiltration of muscles in FSHD [69]. Based on

311 the present relationship between PA and declines in muscle strength, it seems reasonable to

312 suggest interventions that increase PA in adults with BMD may benefit muscle strength, while

313 potentially also alleviating some concerns around changes in fat mass identified in the present

314 study. Future work needs to investigate the benefits of increasing PA, and to further identify

315 psycho-somatic and/or social barriers and facilitators of PA and patterns of SB in this

316 population [70].

317 **Study Limitations**
318 The present study has two main limitations, the first being the sample size. Whilst the sample

319 size recruited is aligned with those identified during the *a Priori* power calculations (See

320 Methods [7, 34]), they are comparably small to some previous longitudinal studies [17, 71].

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321 The present study however does report on longitudinal changes in function and health in a

322 previously unreported sample, adults with DMD [37], and utilises outcome measures that are

323 more sensitive to previous methods. Differences were identified within the present DMD

324 sample size of n = 15, while a Post Hoc calculation for adults with BMD using data from the

325 present study identifies n = 15 required for future studies monitoring lower limb muscle

326 strength. Whilst the recruited BMD sample size in the present study is slightly under-powered,

327 it is considerably larger than that reported previously in natural history studies on adults with

328 BMD [28], and contributes significantly to the currently limited longitudinal data in adults with

329 BMD.

330 Secondly, the present study is limited to 12 months monitoring only, which is comparably

331 shorter than some previous studies [28, 35], however consistent with many previous

332 longitudinal studies in children with DMD [25, 72-74]. The 12 month sample period was long

333 enough however to identify specific changes in LBM (DMD), body fat (BMD), GM ACSA

334 (DMD), PFMVC (DMD), KEMVC (DMD) and 10m walk time (BMD). Regardless, this

335 identification of differences in function and health within a 12 month time period is an

336 important finding itself, and further emphasises the need for continuous health and function

337 monitoring and management in these conditions.

338 All DMD participants will have received some form of steroid treatment through childhood

339 and adolescence. Whereby steroid treatment typically stops upon full-time wheelchair use.

340 Given the data collection from a non-NHS organisation, it is beyond the scope of the present

341 investigation to gain historical steroid treatment and dosage information. Therefore, all data

342 has been presented with the caveat that DMD participants will have historically received steroid

343 treatment, however it should be noted that none were currently receiving steroid treatment.

Future Research

Whilst it is important to further understand the progression of these conditions in what has been previously described as an "unforeseen population" [37], further mechanistic insight is required. Primarily, the reductions in strength in the current study are likely attributed to progressive fat fraction within the muscle, synonymous with the condition [20]. Future research should assess the progression of tissue changes in adults with DMD, however the reduction in GM ACSA in the current study appears consistent with previous hypothesis' that muscle size becomes more representative of contractile tissue quantity in adulthood [42], with the end of the inflammatory induced appearance of psuedohypertrophy. In addition, further understanding of physical behaviours in adults with BMD is required, especially those who retain some form of ambulation, given the present findings on body composition, and previous work demonstrated positive effects of increased step count on contractile tissue in adults with Fascioscapulohumeral MD [75]. More broadly, evidence based nutritional guidelines, with specifics guidance for differing classifications and functional status are required to best manage energy balance and reduce additional strains on health.

Conclusion

In conclusion, the present data describes natural history changes in body composition, strength and physical activity in adults with DMD and BMD. Changes in DMD appear consistent with the understanding of the condition, with 14-19% weaker PFMVC and KEMVC, consistent with paediatric populations [16, 36, 42]. Change in DMD PFMVC was best explained by changes in LBM, GM ACSA and Baseline PFMVC. Within BMD, 12 month changes in PFMVC and KEMVC although not significant, were explained by change in minutes of physical activity. Changes in LBM in DMD and body fat in BMD were both masked by non-significant changes in body mass, furthering the need for specific monitoring of body composition to reduce the development of potential co-morbidities.

Acknowledgements

Conflict of Interest

Data Availability

Data is available upon request to the Author.

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557   **Table 1.** 12 Month changes in body composition, muscle size, lower limb strength and

558   physical activity in Adults with DMD.

	DMD			
	Baseline	12-Months	%Change	95% CI
N			15	
Functional Status	8 (8-8)	8 (8-8)	-	-
Ambulatory Status				

|	Baseline	12 Months	% Change	95% CI
No Walking Support	-	-	-	-
Walking Support	-	-	-	-
Manual Wheelchair	-	-	-	-
Electric Wheelchair	8/8	8/8	-	-
Respiratory Support	15/15	15/15	-	-
Night-time only (%)	13/15	13/15	-	-
24/7 (%)	2/15	2/15	-	-
PEG (%)	4/15	4/15	-	-
Age (years)	24.2 ±6.1	25.2 ±6.1	-	-
Stature (cm)	172.0 ±4.3	172.0 ±4.3	-	-
Body Mass (Kg)	73.1 ±14.6	71.4 ±14.5	-2%	-3.8; 2.8
BMI (Kg/m^2)	25.5 ±4.1	24.5 ±7.5	-4%	-1.6; -0.2
Body Fat (Kg)	24.3 ±9.5	23.7 ±10.8	-3%	-7.3; 0.39
LBM (Kg)	47.6 ±7.7	45.0 ±6.4	-5% *	-3.99; -1.14
GM ACSA (cm^2)	23.3 ±16.5	21.4 ±16.3	-8% *	-3.43; -0.49
PFMVC (N.m)	16.7 ±6.8	13.6 ±6.3	-19% *	-4.79; -1.49
KEMVC (N.m)	12.6 ±8.8	10.8 ±7.0	-14% *	-3.16; -0.31
SB%	96.4 ±4.5	98.5 ±0.02	2%	-0.32; 4.54
TPA^{mins}	13.5 ±16.1	7.17 ±8.9	-47%	-14; 1.7

559 Table 1. One year changes in MD strength, physical activity and function. All data presented and Mean±SD, except for
560 Functional status which is presented as Median (Range), Respiratory Support, Ambulatory Status and PEG are presented as
561 absolute. DMD = Duchenne Muscular Dystrophy; 95% CI = 95% Confidence Intervals PEG = Percutaneous endoscopic
562 gastrostomy; PFMVC = Plantar-Flexion Maximum Voluntary Contraction; KEMVC = Knee Extension maximum Voluntary
563 Contraction; SB% = Sedentary Behaviour %; TPA^{mins} = Minutes of Total Physical Activity; m = metres; s = seconds; †
564 Ambulant BMD only (n=8); *denotes significant changes from baseline.

565 **Table 2.** 12 Month changes in body composition, muscle size, lower limb strength and physical

566 activity in Adults with BMD.

	BMD			
	Baseline	12 Months	% Change	95% CI
N			12	
Functional Status	3.5 (1-7)	3.5 (1-7)	-	-
Ambulatory Status				
No Walking Support	6	6	-	-
Walking Support	3	2	-	-
Manual Wheelchair	1	2	-	-
Electric Wheelchair	2	2	-	-
Respiratory Support	0/12	0/12	-	-
Night-time only	-	-	-	-
24/7	-	-	-	-
PEG	0/12	0/12	-	-
Age (years)	44.1 ±12.6	45.1 ±12.6	-	-
Stature (cm)	178.9 ±6.2	178.9 ±6.2	-	-
Body Mass (Kg)	84.4 ±15.1	85.1 ±16.4	0%	-1.22; 2.64
BMI (Kg/m^2)	26.4 ±4.9	26.6 ±5.4	0%	-0.38; 0.84
Body Fat (Kg)	25.1 ±8.8	26.3 ±8.9	4% *	0.20; 2.19

LBM (Kg)	59.3 ±7.8	58.8 ±8.1	-1%	-2.05; 1.08
Ambulatory	9/12	8/12	-	-
GM ACSA (cm^2)	29.7 ±18.4	26.6 ±14.4	-10%	-6.0; -0.11
PFMVC (N.m)	35.7 ±11.3	33.2 ±12.2	-7%	-6.01; 1.08
KEMVC (N.m)	97.7 ±64.3	83.9 ±56.2	14%	-24.8; -2.6
SB%	83.4 ±7.2	83.9 ±6.3	0%	-4; 5
TPA^{mins}	123.1 ±57.6	120.4 ±50.7	-2%	-17.2; 70.5
10m Walk (s)†	11.0 ±2.9	12.7 ±3.9	15%*	1.4; 3.4

567 Table 2. One year changes in MD strength, physical activity and function. All data presented and Mean±SD, except for
568 Functional status which is presented as Median (Range), Respiratory Support, Ambulatory Status and PEG which are presented
569 as absolute. BMD = Beckers Muscular Dystrophy; 95% CI = 95% Confidence Intervals; PEG = Percutaneous endoscopic
570 gastrostomy; PFMVC = Plantar-Flexion Maximum Voluntary Contraction; KEMVC = Knee Extension maximum Voluntary
571 Contraction; SB% = Sedentary Behaviour %; TPA^{mins} = Minutes of Total Physical Activity; m = metres; s = seconds; †
572 Ambulant BMD only (n=8); *denotes significant changes from baseline.

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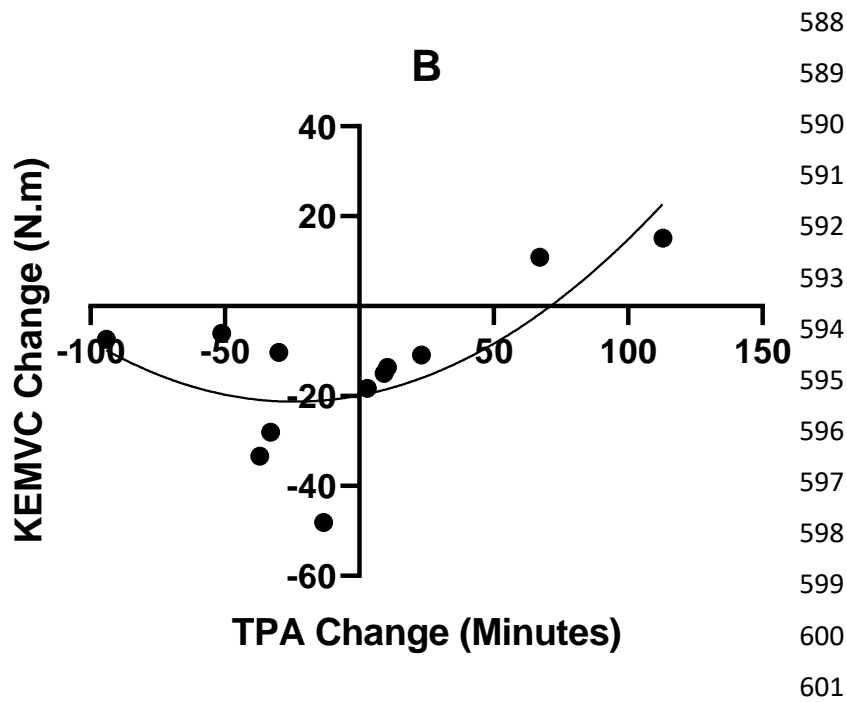578
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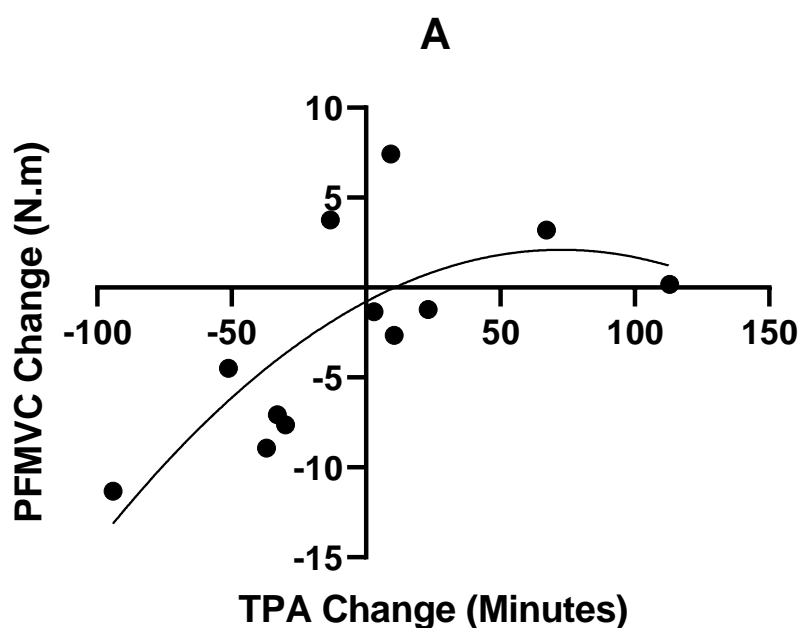
Figure 1. BMD strength change and physical activity change relationships A. PFMVC change and TPA^{mins} change in BMD B. KEMVC change and TPA^{mins} change in BMD. PFMVC = Plantar Flexion Maximal Voluntary Contraction, N.m = Newton Metres, TPA = Total Physical Activity, KEMVC = Knee Extension Maximal Voluntary Contraction.