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John F. Ditunno, Jr
Thomas Jefferson University

Richard E. Verville
Powers Pyles Sutter & Verville PC

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Title: R. Tait McKenzie: Pioneer and Legacy to Physiatry

Authors: John F. Ditunno, Jr., M.D.¹ and Richard E. Verville, JD²

¹Regional Spinal Cord Injury Center of the Delaware Valley, Department of Rehabilitation Medicine, Thomas Jefferson University, Philadelphia, PA 19107;

² Powers Pyles Sutter & Verville PC, Washington, DC

Corresponding Author

John F. Ditunno, Jr., M.D.

Regional Spinal Cord Injury Center of the Delaware Valley

Thomas Jefferson University

132 South 10th Street, 375 Main Building

Philadelphia, PA 19107

Phone: 215-955-6579

e-mail: John.Ditunno@jefferson.edu

fax: 215-955-5152

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6 **TITLE: R. Tait McKenzie: Pioneer and Legacy to Physiatry**

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24 *"In history, a great volume is unrolled for our instruction, drawing the materials of future*
25 *wisdom from the past errors and infirmities of mankind."*

26 **Edmund Burke**

27

28 **INTRODUCTION**

29 Our purpose in this paper is to illustrate scientist and physician R.Tait McKenzie's
30 contributions to the scientific development of physical training and therapeutic exercise in
31 restoring function and reducing disability. McKenzie's legacy to PM&R is his fundamental
32 concept, much later articulated by the American College of Sports Medicine, as to the
33 importance of frequency, intensity, time, type, volume, and progression of therapeutic exercise
34 [1,2]. His classic book [3] instructs physicians for the first time as to the scientific value of
35 exercise in health and disease. He categorizes the specific pathological conditions that can be
36 effectively treated with exercise, and he emphasizes the precision necessary in dosage and timing
37 to achieve the benefit. In the preface to his first book, *Exercise in Education and Medicine* [3],
38 he exposes the medical profession's one-dimensional approach to therapeutics, i.e. an emphasis
39 only on pharmacology, an approach that has prevailed until very recent times [4].

40 *"Perhaps a certain laziness which is inherent in both patient and physician tempts*
41 *to the administration of a pill or draught to purge the system of what should be used*
42 *in normal muscular activity, but there is a wide dearth of knowledge among the*
43 *[medical] profession of the scope and application of exercise in pathologic*
44 *conditions, and the necessity of care in the choice and accuracy of the dosage will be*
45 *emphasized throughout the second part of this book" [3].*

46

47 As a scientist and clinician, McKenzie also recognized the lack of interest by the medical
48 profession in the physiology of exercise and the importance of physical training for promoting
49 good health and function.

50 McKenzie's use of physical therapy in the rehabilitation of the war wounded in Great
51 Britain, Canada, and the United States during World War I (WW I) entitles him to recognition as
52 one of the earliest pioneers of physical medicine and rehabilitation (PM&R). His second
53 textbook, *Reclaiming the Maimed: A Handbook of Physical Therapy* [5], was used by the
54 military in all three countries to develop and establish physical therapy services in the
55 Reconstruction Hospitals during WW I. His work influenced physiatrists Frank Granger, George
56 Deaver [6] and John Stanley Coulter, three major leaders in the field in the decades following the
57 war.

58

59 **EARLY INFLUENCES: MCGILL, HARVARD, AND SPRINGFIELD**

60 McKenzie experienced a "fascination [with] acrobatics and gymnastics" during his early
61 undergraduate years at McGill University [7]. He competed in track and field and set the
62 intercollegiate high jump record in 1886 before entering medical school. During his medical
63 school days, he developed his first interests in physical education and was inspired by Dudley A.
64 Sargent, MD, who conducted a six-week course at the Harvard Summer School [8]. McKenzie
65 attended courses for two summers in 1889-1890 on the theory of systems in physical education,
66 anthropometry, applied anatomy and other sciences, which were applied in class drills involving
67 exercises with weights, vaulting with bars and horses, tumbling and dancing. Sargent's
68 systematic measurement of body proportions and research involving thousands of male and
69 female students that included physiological studies of respiratory capacity and grip strength,

70 established that training approaches must be scientifically based. This same scientific rigor is
71 evident in McKenzie's future cardiac studies [9]. Many of the machines used in gymnasiums
72 throughout the United States such as rowing, pulley systems for specific muscle groups, and
73 lifting were developed by Sargent. However, Sargent faced opposition to his scientific
74 approaches to the study of physical conditioning by the conservative elements of academe. But,
75 McKenzie predicted that Sargent's place in the history of physical education would be as
76 "pioneer, thinker and scientist" [10].

77 It was during medical school at McGill University that McKenzie began to instruct
78 students in gymnastics under the direction of James Naismith, Director of Athletics [11].
79 McKenzie's interest in exercise physiology developed during his years at the University, as is
80 reflected in his appointment as Medical Director of Physical Training following graduation from
81 medical school. Naismith would subsequently join another of Sargent's students, Luther H.
82 Gullick, MD, who was a pioneer in physical education and founded the first school at Springfield
83 College. (Naismith and Gullick are credited with the invention of the game of basketball [12]).
84 Following graduation from medical school, McKenzie became a close friend of and collaborator
85 with Gullick and the two trained new directors of the YMCA in physical education. Gullick
86 offered McKenzie a position at the YMCA in Springfield [13], but McKenzie chose not to join
87 the YMCA for professional and personal reasons. McKenzie also taught anatomy at McGill and
88 his appreciation of anatomy, kinesiology and sports was soon reflected in his art as a sculptor
89 (Figure 1), which would earn him international recognition [14].

90 Although McKenzie had no specialized training in general surgery or orthopedic surgery
91 following his internship in Montreal he restricted his practice to orthopedics and musculoskeletal
92 diseases after he joined the faculty of the medical school at McGill. Graduates of Canadian and

93 US medical Schools in the 1890s were licensed to practice medicine and surgery following an
94 internship of 1 year. If they restricted their practice to one field, such as orthopedic surgery, on a
95 full time or almost full time basis (personal communication Dr. David B. Levine), this validated
96 them as a specialist. McKenzie's earliest publications [15] deal with posture/exercises in the
97 prevention/treatment of scoliosis, and he is characterized later as an orthopedic surgeon with a
98 special interest in "orthopedic gymnastics" [16].

99

100 **UNIVERSITY OF PENNSYLVANIA**

101 Physiatrist Frank Krusen, considered the father of physical medicine [17] claims in his
102 accounts that McKenzie was the first professor of physical therapy in the nation [18], and
103 certainly he was one of the earliest to hold that appointment in a major US medical school - the
104 University of Pennsylvania, the oldest medical school in the nation. McKenzie's appointment as
105 Professor of Physical Therapy in 1907 [19] followed his appointment as Professor of Physical
106 Education in 1904. His early teaching included instruction in exercises that are applicable to
107 "curvature of the spine [and] locomotor ataxia", included in course work in physical education
108 for medical students [20] at the University. However, the Physical Laboratory was not
109 established in the hospital for the training in hydrotherapy and other therapies as part of medical
110 education until 1911-1912 [21]. Archival documents record that "Dr. Joseph Nylin, a trained
111 masseur...graduated from the University of Pennsylvania" joined the faculty as an associate to
112 McKenzie in 1912 [22]. Sophomore medical students were given a series of lectures twice a
113 week on exercises and massage for specific diseases; additional lectures were given to senior
114 students during medicine and surgery rotations. Demonstrations of hydrotherapy and other
115 physical modalities were added as the curriculum evolved [21].

116 Because of his dual role teaching physical education and physical therapy, McKenzie was
117 effective in introducing training programs in physical examination and exercise to improve the
118 health and correct educational deficiencies in the student population. In addition to these
119 innovative contributions to medical education, he made scientific observations and published his
120 findings in the medical literature during these early years at the University [23]. It is during this
121 period McKenzie began to write his classic textbook on exercise in health and disease. He states
122 his reasons for doing so in the following notation [19] shortly after his arrival at Penn in 1904:

123 *“Living in Philadelphia, the home of the leading Medical publishers, and with a seat on a*
124 *Medical faculty, each member of which had written a standard textbook on his subject, it*
125 *was natural that the subject of writing would come up early.” [19]*

126 McKenzie is in fact approached by a leading publisher and finds that “at the time there are no
127 textbooks on the subject” [19]. Only one book had been published on exercise at that time,
128 Ferrand LaGrange’s *Physiology of Bodily Exercise* [24]. But McKenzie held the view that “in the
129 realm of medicine...no attempt had been made to give a comprehensive view of the whole
130 subject” [18]. McKenzie’s textbook, *Exercise in Education and Medicine*, was first published in
131 1909 [3] and is regarded by the founders of sports medicine and historians of physical education
132 as a classic [4,25]. It is praised as the “most comprehensive volume” that “brought physical
133 medicine, rehabilitation and athletic knowledge together” [26,27]. Berryman [4] places it with
134 Sargent’s book in linking exercise with health and medicine. Part I is devoted to the
135 classification of exercise, massage, physiology of exercise, the German and Swedish schools of
136 exercise, and physical education in schools and for recreation. The second part of the book
137 focuses on the use of exercises in pathological conditions effecting posture, cardiovascular
138 disorders, neurological diseases such as locomotor ataxia, and treatments for obesity and

139 musculoskeletal conditions. He is very precise in describing the accompanying symptoms and
140 physical findings such as loss of balance with ataxia. He cites Silas Weir Mitchel, considered the
141 father of neurology in USA, who explained a treatment protocol based on the exercises of
142 Frankel, a German neurologist.

143 *“The exercise treatment of ataxia...was used 40 years ago in America by Dr. Weir*
144 *Mitchell...invented by Frankel, of Heiden [Germany]. ...rising from a chair the tabetic*
145 *patient usually forgets to draw his feet backward. ...He has ... to learn this simple*
146 *coordination over again [3].”*

147 With drawings, McKenzie maps out the progression of training exercises to restore balance
148 during walking, indicating a favorable prognosis, and then he applies additional exercises for
149 dressing and other activities of daily living. He cautions that the training of individuals should
150 avoid excessive fatigue and advises monitoring pulse rate and respiratory parameters. This
151 textbook includes the first comprehensive discussion of the “dosage” essential in the use of
152 therapeutic exercise, and this discussion becomes the foundation for the prescription of exercise
153 in PM&R [2].

154 McKenzie’s 1913 publication on the influence of exercise on the heart [9] reflects his
155 interest in cardiovascular physiology and cardiac rehabilitation, an interest that continues
156 throughout his career. Dr. Joseph Wolffe, a cardiologist and one of the founders of the American
157 College of Sports Medicine, praises McKenzie’s early attention to cardiovascular exercise [25].

158 *“Dr. McKenzie demonstrated, time and again, that response to exercise with few*
159 *exceptions, proved to be a sound clinical test of the heart’s ability to perform work and*
160 *that functional heart murmurs, certain cardiac irregularities were untrustworthy guides*
161 *in the evaluation of the integrity of the heart.”*

162 THE GREAT WAR

163 Orthopedic surgeons at the beginning of the 20th century, such as Robert Lovett [28],
164 Robert Jones, Joel Goldthwait, Fred Albee, and Henry Kessler, had a comprehensive approach to
165 the restoration of function that extended beyond their surgical skill. Several worked with
166 physical therapy aides in civilian hospitals before the war, and the aides complemented the
167 surgeon's efforts. These orthopedic surgeons also understood the importance of occupational
168 therapy and vocational training. Kessler emphasized this appreciation in his book "The Knife is
169 Not Enough" [29]. McKenzie was part of this tradition, but he brought a dimension of
170 therapeutic exercise, which he extended into muscle re-education, functional training,
171 gymnastics, sports and dancing. Opportunities to employ these unique aspects of therapeutic
172 exercise were soon to unfold with events in Europe and the United States.

173 The advent of WW I provided an opportunity for physicians with interests in physical
174 training and physical therapy to apply their skills to both enhance the fitness of inductees and
175 restore function to the wounded and those with medical and post-surgical conditions.
176 McKenzie's patriotic fervor led him to take a leave of absence from the University for 18 months
177 to join British forces in 1915 at the beginning of the War (Figure 2). He came under the
178 command of Sir Robert Jones, "who founded the chain of orthopedic centers, to which
179 reconstructive centers were attached" [5]. McKenzie indicates in a 1917 paper [30] on the
180 treatment of neurological injuries that this approach attracted the attention of the Surgeon
181 General of the United States.

182 *"In the great orthopedic centers established throughout England by*
183 *Lieutenant-Colonel Sir Robert Jones...[which] form[ed] the backbone of the*
184 *treatment... the Surgeon General of the United States has already sent over a*

185 *contingent of orthopedic surgeons to make themselves familiar with the subject*
186 *and to establish centers to accommodate thirty-five thousand cases in France.”*

187 McKenzie’s first task was to assess the health status of soldiers determine unfit for service in the
188 army.

189 *“Arriving in England in 1915 he was distressed by the sight of many men who were*
190 *unfit... Dr. McKenzie substituted health education, remedial physical training and*
191 *recreation...in the place of rest, inactivity and a life akin to hibernation. His experiments*
192 *proved to be the most effective in hastening recovery of the sick... Gradually, it gained*
193 *acceptance that properly supervised physical education revitalizes while prolonged rest*
194 *devitalizes and cripples” [25].*

195 McKenzie’s treatment approaches for wounded soldiers combined traditional physical
196 therapy modalities with his innovative concepts of precise therapeutic exercise programs,
197 occupational therapy, and vocational retraining. His approach to the restoration of function of
198 nerve injuries represents one of the first descriptions of the use of graded exercises with
199 hydrotherapy and antigravity exercises. He reported [30] on a series of more than 500 cases
200 (1917) in which he employed a system for grading of muscle strength and then applied muscle
201 reeducation programs appropriate to the muscle strength. The muscle reeducation he describes as
202 “progressive active movements...to bring back and strengthen voluntary power and later,
203 gymnastic and vocational training”. This approach is similar to Lovett’s approach with polio
204 cases [31] refined by Robert Bennett at Georgia Warm Springs in the 1940s [32].

205 McKenzie’s appreciation of the benefits of occupational therapy and especially the use of
206 adaptive equipment is unique for a military physician in 1916. His understanding of the

207 distinction between occupational therapy and vocational training is clearly defined in his
208 textbook [5]:

209 *“A distinction is frequently drawn between occupational therapy and vocational*
210 *training. In the former, the movements are given as treatment, and the work done*
211 *is a secondary consideration. The patient saws wood because the arm muscles can*
212 *thus be contracted and relaxed a definite number of times. It is really a gymnastic*
213 *exercise done with a saw. In vocational training the object is to make a good box*
214 *by sawing the board in definite lengths, and the arm exercise is secondary, though*
215 *essential.”*

216 In a letter [33] to the editor of the Journal of the American Medical Association (JAMA) in 1918,
217 he identifies “devices for men who have lost one or two arms” and this appears to be early
218 examples of adaptive feeding and recreational equipment for the upper extremity amputees
219 (Figure 3).

220 It is these scientific studies, case reports, and his success returning more than 70 % of the
221 war wounded under his care at Heaton Park to active service [34,35], which established his
222 reputation in military circles as an expert in functional restoration of wounded soldiers.
223 McKenzie recognized the need for a physical therapy textbook to guide army physicians since
224 no text in English existed for the military at the time. He approached the development of his
225 handbook of physical therapy in the same fashion as his book on exercise in 1909, drawing from
226 exercises in the Swedish and German literature and improvising concepts of mechanotherapy
227 [34] that were influenced by Sargent and others. Granger [36] and Lovett [28] cite McKenzie’s
228 publications and expertise in mechanotherapy, which involved “machines” or apparatus for

229 active and passive exercises to increase finger, wrist, shoulder and lower extremity range of
230 motion and strength.

231 McKenzie's work on the rehabilitation of the "crippled soldier" was well known by
232 leaders in US medicine and surgery and is cited in W.W. Keen's classic surgical textbook [37].
233 Harry Mock, a pioneer industrial surgeon in the Surgeon General's Office, advised Frank
234 Billings, Head of Reconstruction and Rehabilitation in WW I, that McKenzie was "the only man
235 for the job" [38] to advise the US Army regarding physical therapy, and as a result Billings
236 invited McKenzie "*to take charge of the department of physiotherapy to standardize the work*
237 *and to secure the proper personnel in physiotherapy that will enable us to do that work well*"
238 [39].

239 The subsequent success of rehabilitation hospitals in the US has been attributed to the
240 pioneering efforts of US military physicians, such as Frank B. Granger, who set up the program
241 of physical therapy in the US Army reconstruction hospitals [40]. The program that Granger
242 implemented, however, was based on his visit to the British Army with Joel Goldthwait, head of
243 Orthopedic Surgery for the American Expeditionary Forces and their observations of the
244 program in reconstruction hospitals of Great Britain that had been established under the
245 leadership of McKenzie [27]. Granger's approach in the convalescent hospitals in France and the
246 US, like McKenzie, stressed the team approach to rehabilitation. McKenzie's scientific
247 publications before and during the war [30,34,35] and his *Handbook on Physical Therapy:*
248 *Reclaiming the Maimed* [5], the official text and standard for British, Canadian and US armed
249 forces, must have influenced all [28,36] who shared it including professionals at the convalescent
250 facility in France that physiatrist John Stanley Coulter headed [41].

251

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253

254 INFLUENCE ON GRANGER, MOCK, COULTER AND DEEVER: 1919-1930

255 Developments in the United States immediately following the war reflected the
256 translation of these war experiences into civilian practice. The physical treatments developed by
257 physicians in convalescent hospitals, pioneered by McKenzie and others, “formed the basis for
258 modern Physical Medicine”[27]. For example, psychiatric leaders Coulter, Granger, and Mock
259 transitioned their efforts to raise the standards of research, education and practice in physical
260 therapy, since many of the empirical claims were unsubstantiated, considered suspect and at
261 times fraudulent by medical professionals. McKenzie’s emphasis on the requirements of
262 scientific rigor is reflected in their work. Organizations were formed of physicians with special
263 expertise in physical medicine and of physical therapy aides; both groups recognizing the need to
264 improve the standards of training (Table 1A).

265 Coulter became very active in one of several new organizations of physical therapy
266 physicians (Table 1A), the Congress of Physical Therapy (CPT) founded in 1923. His
267 connections to Granger and Mock during the war [42] are well documented, and within several
268 years he was elected the third president of the CPT. Granger founded and served as first
269 president of the Academy of Physical Therapy (APM), established in 1923 the same year as the
270 Congress of Physical Therapy. The APM was an organization which included former
271 electrotherapists, but many physical medicine physicians belonged to both organizations [43,44].
272 Both Granger and Coulter were strong advocates of improving the educational standards of
273 physical therapy aides following the war, and both were commended in historical accounts
274 [45,46] of the American Physical Therapy Association (APTA). McKenzie’s influence can be

275 seen in the efforts of Granger and Coulter to strengthen the team approach to rehabilitation in
276 these organizations. These physician pioneers, like McKenzie [34], recognized that the physical
277 therapist aide's knowledge and skill was integral to raising the standards of physical therapy in
278 medical practice.

279 The creation of the AMA Council of Physical Therapy (AMACPT) in 1926 [47] was the
280 first official recognition of physical therapy physicians. The AMACPT was chaired by Mock,
281 who was well-versed in McKenzie and Granger's contributions. Most of the early reports of the
282 AMACPT dealt with safety and standardization of therapeutic modalities of heat, electricity, and
283 radium, with far less attention to therapeutic exercise, although exercise was listed as one of six
284 categories in the definition of modalities [47]. The following definition most likely reflects
285 McKenzie's influence on Mock:

286 *Therapeutic Exercises.—Muscle training exercises, passive and active, mechanotherapy,*
287 *occupational therapy, games.*

288 While Mock was knowledgeable of physical therapy in his practice in Industrial Medicine, he
289 was not a full time practitioner.

290 Frank Granger, however, who was appointed to the AMACPT in 1927 was the first full
291 time physical therapy physician [48]. Granger, while on the AMACPT, recognized McKenzie's
292 contribution to the invention of mechanical exercise equipment and the benefits of exercise in
293 competitive sports in addition to the need for better research to validate physiotherapy [36].
294 Following Granger's death in 1928, he was succeeded by Coulter to the AMACPT in 1931
295 ensuring continuity by full time practitioners of physical medicine. Although McKenzie was not
296 directly involved in these deliberations he continued to publish and present papers on sports and
297 to physical therapy societies [49,50] (Figure 4).

298 Deaver, considered the grandfather of rehabilitation medicine [6], was likely exposed to
299 the physical therapy course taught by McKenzie and Nylin when he was a sophomore and senior
300 at the University of Pennsylvania before he entered the military. Deaver, a recent medical school
301 graduate in 1917, familiar with the YMCA approach to physical training, also employed drills
302 accompanied by music in his fitness training for soldiers [51]. Like McKenzie, Deaver applied
303 exercise therapy and other physical therapies to rehabilitate the war wounded of WW I.
304 McKenzie [52] and Deaver published back-to-back articles in the journal for directors of
305 YMCA's on treatment of the war wounded [51,52]. Both trained masseurs and other staff to
306 provide physical training, and both recognized that restoration of function was a team effort
307 [53]. McKenzie and Deaver continued a relationship after the War during Springfield College
308 reunions in Philadelphia in 1921 [54].

309 It is interesting to speculate on how these early experiences and Deaver's association
310 with McKenzie may have influenced his choice of joining Coulter at Northwestern in 1930 [6],
311 and his subsequent move to NYC, where his career in PM&R unfolds, first with Coulter, then at
312 the Institute for the Crippled and Disabled (ICD), and later with Rusk at New York University
313 (NYU).

314 This approach of restoring the war wounded to optimal functioning with a team effort,
315 first reported by McKenzie and Deaver in WW I, was expressed again in Deaver's relationship
316 with Howard Rusk. Early in WWII, Rusk approached Deaver, when he met him at the ICD and
317 asked his advice regarding the establishment of rehabilitation centers for the Air Force. "Do you
318 think you could set up such a program?" Deaver replied that they had already offered such a
319 program to the Army and VA, but was told it was not needed. Rusk replied "We need it in the
320 Air Force" and Deaver replied "We'll be glad to do it for you" [55, p 3-29].

321 The year 1930 is significant for the field of PM&R, because a number of important
322 events occurred in the lives of these early pioneers. Following Granger's death, Coulter
323 succeeded him on the AMACPT, McKenzie retired, and Deaver joined Coulter at Northwestern
324 University. Krusen began publishing on physical therapy, which led to his recruitment to the
325 Mayo Clinic and his departure from Temple University in 1935 [17] (Table 1B).

326

327 **INFLUENCE ON PHYSICAL MEDICINE 1931-1938 AND BEYOND**

328 In 1934, McKenzie became active in the Academy of Physical Medicine (APM),
329 originally founded in 1923 by Granger as the Academy of Physical Therapy [44]. McKenzie
330 chaired a symposium at the annual APM meeting in 1936, which featured the first Director of
331 the London Hospital Department of Physical Medicine, Sir Robert Stanton Woods, two
332 national experts from Columbia University and the Sargent School in physical education, and a
333 presentation on exercise physiology from the Harvard Fatigue Laboratory (HFL). This was an
334 example of efforts to update physical medicine in regard to exercise physiology and physical
335 education. Inviting participation by a member of the HFL illustrates his visionary leadership
336 concerning the importance of the physiology of exercise as a necessary component of future
337 research in PM&R. His judgment in 1936 is validated, since The Harvard Fatigue Laboratory,
338 when viewed 6 decades later, is recognized as having attracted some of the most important
339 leaders in this field [56]. Robert Darling [57] former chair of PM&R at Columbia and Edward
340 Gordon of Chicago and Jefferson Medical College are products of this research environment in
341 the 1940s.

342 Although, McKenzie like Deaver [58] did not play a major role in organized PM&R, he
343 was elected president of the APM in 1938. This is a critical year in the development of Physiatry

344 as a specialty. McKenzie is aware of the achievements of the AMA Council on Physical Therapy
345 and recognized this in his presidential letter to the members of the ACP in 1938 [43].

346 *“Every profession must have an organization such as ours, composed of its*
347 *leaders...capable of...cultivation of their own special field. It is especially necessary in*
348 *work such as ours which has so recently attained official recognition...keeping fellows*
349 *informed...with new discoveries in Physical Medicine”*

350 In 1937, Krusen was informed by his colleagues at Mayo that the time for consideration
351 of a specialty board had arrived [42]. Krusen and the leadership of the CPT had already
352 approached the APM, while McKenzie was an officer, to consolidate with the Congress of
353 physical therapy. This was a strategy in preparation for the formation of the Society of Physical
354 Therapy Physicians (SPTP), whose primary purpose was to work for specialty status [58]. It is
355 unclear what McKenzie’s position was on this movement since he died prior to the meeting, but
356 events unfold and leadership for these efforts are identified in the next two years, and the
357 outcome was momentous for PM&R. In 1938 Krusen is elected president of CPT and Coulter
358 becomes the first president of the newly formed Society of Physical Therapy Physicians. This
359 organization became the American Academy of Physical Medicine (AAPM&R) in 1954.
360 Although Krusen was named chair of the Research Committee of the APM by McKenzie,
361 together with Mock and Albee in 1938, he continued his efforts toward consolidation and
362 through his leadership in the Congress for the future recognition of the Board of PMR. The
363 members of the APM became absorbed into the SPTP and the Congress over the next few years;
364 in Coulter’s history of physical medicine in 1946 [48] he names only two organization
365 representing physical medicine, the Congress and the Society of Physical Medicine.

366 Many of these pioneers who were former members of the APM and of the CPT (later the ACRM
367 (Table 1B) and played key roles on behalf of the specialty during and/or following the war, will
368 be recognized by the ACRM's Gold Key Award [59]. These leaders included Goldthwaite
369 (1935), Mock (1937), Coulter (1943), Krusen (1944), Deaver and Kessler 1953.

370 McKenzie's legacy at the University of Pennsylvania is well documented [60]. Dr.
371 Joseph Nylin, who succeeded him in 1931 presented a paper at APM in 1938 together with
372 Krusen and Walter Zeiter [61]. Nylin is listed as one of the charter members of the SPTP the
373 following year [58], and this links McKenzie's legacy at Penn with the future AAPM&R.
374 Following Nylin's death in 1945, George Morris Piersol, an orthopedic surgeon who was well
375 known to McKenzie, succeeds him. Piersol gained national recognition in PM&R and received
376 the Gold Key Award of the Congress in 1954 joining many of the earlier pioneers. Piersol
377 groomed William Erdman as his successor that same year and Erdman became a major physiatric
378 leader during the next 3 decades.

379

380 **CONCLUSION**

381 McKenzie's vision of physical medicine and rehabilitation (PM&R) through the prism of
382 physical education reveals the major taproot that fed the early growth of Physiatry. As a scientist
383 with an appreciation of exercise physiology, and as a physician with an understanding of the
384 pathophysiology of trauma and disease, he was able to apply accurate anatomic, physiologic, and
385 kinesiological measurements, develop specific training programs and design recreational and
386 vocational activities to restore maximum function without injury or other negative outcomes for
387 patients with many different conditions. He was perhaps the first physician scientist to articulate
388 the concepts we embrace today for retraining individuals with sports injuries and neurotrauma.

389 His national stature as a pioneer in sports medicine, an artist, a physical educator and PM&R
390 physician [25,27,62] is well-deserved. His legacy to the practioners of PMR such as Granger,
391 Coulter, and Deaver extends to partners in physical and occupational therapy, kinesiology and
392 biomechanics, because he understood these basic concepts and appreciated the requirement of a
393 team effort to achieve the best results.

394

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643 **Tables**

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645 **Table 1 A.** Timelines for organizations and abbreviations for Physical Therapy (Physical

646 Medicine and Rehabilitation) organizations.

Name	abbreviation	Membership
American Society of Physical Therapy Physicians 1938	ASPTP or SPTP	Physiatrists requiring Board certification
American Society of Physical Medicine 1944	ASPM	
American Society of Physical Medicine and Rehabilitation 1951	ASPM&R	
American Academy of Physical Medicine and Rehabilitation 1955	AAPM&R	
American College of Radiology and Physiotherapy 1923	ACRP	Physiatrists and related medical professionals
American Congress of Physical Therapy 1925	ACPT	
American Congress of Physical Medicine 1944	ACPM	
American Congress of Physical Medicine and Rehabilitation 1952	ACPM&R	
American Congress of Rehabilitation Medicine	ACRM	
American Academy of Physical Therapy 1923	AAPT or APT	Physicians with interest/skill in Physical Medicine
American Academy of Physical Medicine 1933-1944	AAPM	

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Table 1 B. Timelines Pioneers in Physical Medicine and Rehabilitation

Leaders	Years	Title	Organization	Events
McKenzie	1904-7 to 1930	Professor	University of Pennsylvania School of Medicine	1 st Professor of Physical Education & Physical Therapy in US. “Interest in orthopedic gymnastics” (Packard)
McKenzie	1915- 19	Major	British Armed Forces & consultant to Canadian & US Armed forces	WW I 1 st Handbook Physical Therapy in US.
Granger	1906- 1917	Instructor	Tuft & Harvard Medical Schools	Major interest electrotherapeutics
Granger	1917- 19	Colonel	US Army	WW I Head Physical Therapy US Army
Granger	1919- 1929	Assistant Professor	Tufts Medical School	APT 1923 Founder AMA Council Physical Therapy 1 st Physical Therapist MD 1926
Coulter	1911- 1920	Lieutenant Colonel	US Army (1911-20)	WW I Head 1 st US Convalescent Rehabilitation Hospital in France 1918
Coulter	1926- 1949	Professor & Chair	Northwestern University.	President Congress 1926 AMA Council PT 2 nd MD 1931
Krusen	1926- 1935	Associate Dean	Temple Medical School	Physical Medicine 1 st Physical Medicine Department US
Krusen	1935- 1965	Professor & Chair	Mayo Clinic; University of Minnesota Medical School.	President APM 1936 1938 SPTP with Coulter 1947 Chair ABPMR
Deaver	1931- 1932	Instruct	Northwestern University School of Medicine	Joins Coulter
Deaver	1932- 1937-	Medical Advisor	NYU School PT	Directed training in therapeutic exercises, surgery and orthopedic surgery
Deaver	1938- 1946	Director	Institute Crippled & Disabled	Publishes 1 st Text Activities of Daily Living (ADL)
Deaver	1947- 1969	Professor	Institute PM&R	
Rusk	1940s	Major	US Army	WW II Rehabilitation Hospitals
Rusk	1945- 1980	Professor & Chair	New York University	Founded Institute PM&R

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Figure Legends

Figure 1 - Flying Sphere. McKenzie was a world renowned sculpture of athletes [14,25,27] and the Flying Sphere was modeled from a study in motion by Muybridge. Courtesy of the University of Pennsylvania Archives.

Figure 2 - Major McKenzie at Heaton Park Depot, England 1915. Courtesy of University of Pennsylvania Archives.

Figure 3 - Illustration of mechanotherapy for finger injury [34]. Machine for exercising the fingers. First position. Finger extended. Movement. Flexion at the meta-carpophalangeal joints. Movement represented by dotted lines. (Weights In ounces).

Figure 4 - R. Tait McKenzie. Professor of Physical Education and Professor of Physical Therapy at University of Pennsylvania. Courtesy of the University of Pennsylvania Archives

Figure 1
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Figure 2
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Figure 3
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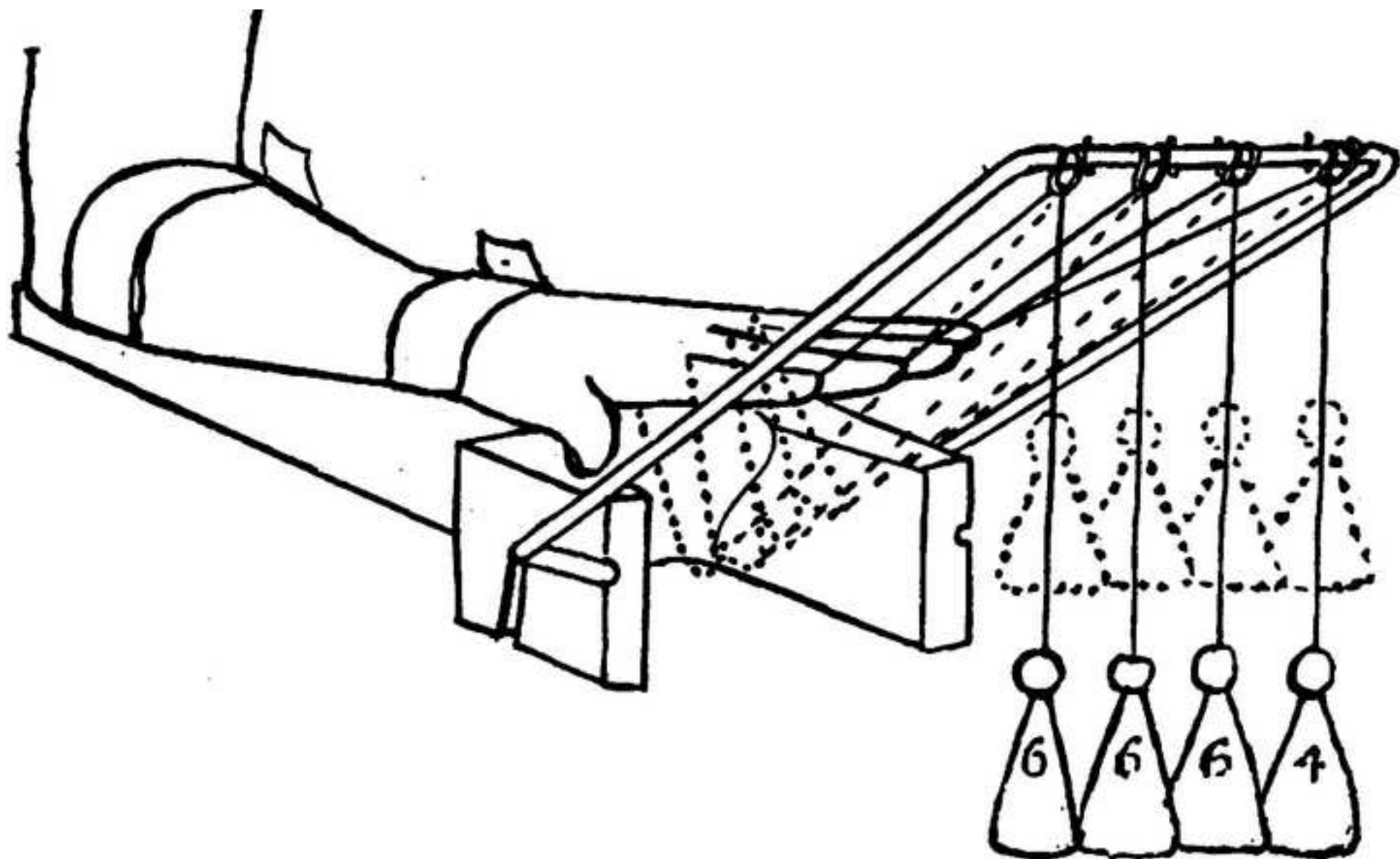


Figure 4
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