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(54) **PERSUASIVE MOTIVATION FOR ORTHOPEDIC TREATMENT**

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(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

823,712 A 6/1906 Uhlmann
4,499,900 A 2/1985 Petrofsky et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CA 3193419 A1 3/2022
CN 2885238 Y 4/2007
(Continued)

OTHER PUBLICATIONS

HCL Fitness, HCI Fitness PhysioTrainer Pro, 2017, retrieved on Aug. 19, 2021, 7 pages, https://www.amazon.com/HCI-Fitness-Physio Trainer-Electronically-Controlled/dp/B0759YMW78/.
(Continued)

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(57) **ABSTRACT**

In one embodiment, a method is disclosed. The method includes, while the patient uses the treatment apparatus, controlling, based on a treatment plan for a patient, a treatment apparatus. The method includes receiving, by a processing device, data from an electronic device, wherein the data comprises one of a position of a body part of the patient or a force exerted by the body part. The method includes storing, via the processing device, the data for the patient in a computer-readable medium. The method includes causing, via a processing device, presentation of a user interface on a patient interface. The user interface comprises an adjustment confirmation control, and the adjustment confirmation control is configured to solicit a response regarding the patient's comfort level with the one
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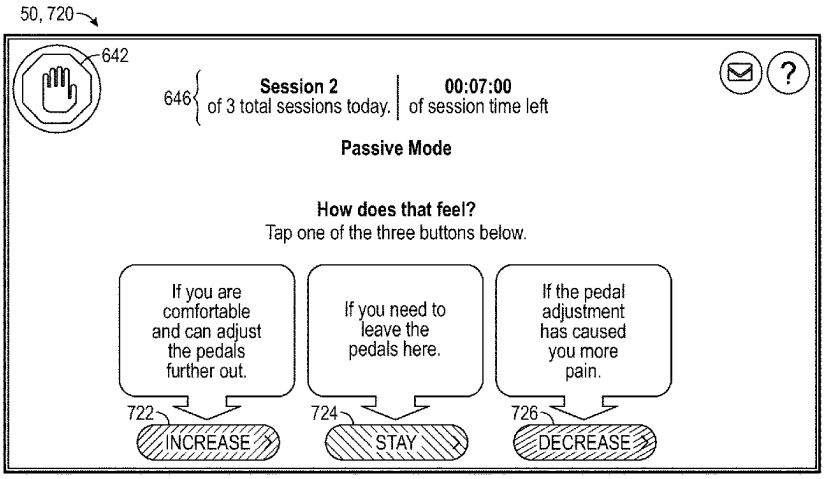

of the position of the body part or the force exerted by the body part.

20 Claims, 16 Drawing Sheets

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(56) **References Cited**

U.S. PATENT DOCUMENTS

4,822,032	A	4/1989	Whitmore et al.	
4,860,763	A	8/1989	Schminke	
4,869,497	A	9/1989	Stewart et al.	
4,932,650	A	6/1990	Bingham et al.	
5,137,501	A	8/1992	Mertesdorf	
5,161,430	A	11/1992	Febey	
5,202,794	A	4/1993	Schnee et al.	
5,240,417	A	8/1993	Smithson et al.	
5,247,853	A	9/1993	Dalebout	
5,256,117	A	10/1993	Potts et al.	
D342,299	S	12/1993	Birrell et al.	
5,282,748	A	2/1994	Little	
5,284,131	A	2/1994	Gray	
5,316,532	A	5/1994	Butler	
5,318,487	A	6/1994	Golen	
5,324,241	A	6/1994	Artigues et al.	
5,336,147	A	8/1994	Sweeney, III	
5,338,272	A	8/1994	Sweeney, III	
5,356,356	A	10/1994	Hildebrandt	
5,361,649	A	11/1994	Slocum, Jr.	
D359,777	S	6/1995	Hildebrandt	
5,429,140	A	7/1995	Burdea et al.	
5,458,022	A	10/1995	Mattfeld et al.	
5,487,713	A	1/1996	Butler	
5,566,589	A	10/1996	Buck	
5,580,338	A	12/1996	Scelta et al.	
5,676,349	A	10/1997	Wilson	
5,685,804	A	11/1997	Whan-Tong et al.	
5,738,636	A	4/1998	Saringer et al.	
5,860,941	A	1/1999	Saringer et al.	
5,950,813	A	9/1999	Hoskins et al.	
6,007,459	A	12/1999	Burgess	
D421,075	S	2/2000	Hildebrandt	
6,053,847	A	4/2000	Stearns et al.	
6,077,201	A	6/2000	Cheng	
6,102,834	A	8/2000	Chen	
6,110,130	A	8/2000	Kramer	
6,155,958	A	12/2000	Goldberg	
6,162,189	A	12/2000	Girone et al.	
6,182,029	B1	1/2001	Friedman	
D438,580	S	3/2001	Shaw	
6,253,638	B1	7/2001	Bermudez	
6,267,735	B1 *	7/2001	Blanchard	A61H 1/024 601/33
6,273,863	B1	8/2001	Avni et al.	
D450,100	S	11/2001	Hsu	
D450,101	S	11/2001	Hsu	
D451,972	S	12/2001	Easley	
D452,285	S	12/2001	Easley	
D454,605	S	3/2002	Lee	
6,371,891	B1	4/2002	Speas	
D459,776	S	7/2002	Lee	
6,413,190	B1	7/2002	Wood et al.	
6,430,436	B1	8/2002	Richter	
6,436,058	B1 *	8/2002	Krahner	A63B 21/4025 600/587
6,450,923	B1	9/2002	Vatti	
6,474,193	B1	11/2002	Farney	
6,491,649	B1	12/2002	Ombrellaro	
6,514,085	B2	2/2003	Slattery et al.	
6,535,861	B1	3/2003	OConnor et al.	
6,543,309	B2	4/2003	Heim	
6,589,139	B1	7/2003	Butterworth	
6,601,016	B1	7/2003	Brown et al.	
6,602,191	B2	8/2003	Quy	
6,613,000	B1	9/2003	Reinkensmeyer et al.	
6,626,800	B1	9/2003	Casler	
6,626,805	B1	9/2003	Lightbody	
6,640,122	B2	10/2003	Manoli	
6,640,662	B1	11/2003	Baxter	
6,652,425	B1	11/2003	Martin et al.	
6,820,517	B1	11/2004	Farney	
6,865,969	B2	3/2005	Stevens	
6,890,312	B1	5/2005	Priester et al.	
6,895,834	B1	5/2005	Baatz	
6,902,513	B1	6/2005	McClure	
7,058,453	B2	6/2006	Nelson et al.	
7,063,643	B2	6/2006	Arai	
7,156,665	B1	1/2007	OConnor et al.	
7,156,780	B1	1/2007	Fuchs et al.	
7,169,085	B1	1/2007	Killin et al.	
7,204,788	B2	4/2007	Andrews	
7,209,886	B2	4/2007	Kimmel	
7,226,394	B2	6/2007	Johnson	
RE39,904	E	10/2007	Lee	
7,406,003	B2	7/2008	Burkhardt et al.	
7,507,188	B2	3/2009	Nurre	
7,594,879	B2	9/2009	Johnson	
7,628,730	B1	12/2009	Watterson et al.	
D610,635	S	2/2010	Hildebrandt	
7,778,851	B2	8/2010	Schoenberg et al.	
7,809,601	B2	10/2010	Shaya et al.	
7,815,551	B2	10/2010	Merli	
7,833,135	B2	11/2010	Radow et al.	
7,837,472	B1	11/2010	Elsmore et al.	
7,890,342	B1	2/2011	Yruko	
7,955,219	B2	6/2011	Birrell et al.	
7,969,315	B1	6/2011	Ross et al.	
7,988,599	B2	8/2011	Ainsworth et al.	
8,012,107	B2	9/2011	Einav et al.	
8,021,270	B2	9/2011	D'Eredita	
8,038,578	B2	10/2011	Olrik et al.	
8,079,937	B2	12/2011	Bedell	
8,113,991	B2	2/2012	Kutliroff	
8,172,724	B2	5/2012	Solomon	
8,177,732	B2	5/2012	Einav et al.	
8,287,434	B2	10/2012	Zavadsky et al.	
8,298,123	B2	10/2012	Hickman	
8,371,990	B2	2/2013	Shea	
8,419,593	B2	4/2013	Ainsworth et al.	
8,465,398	B2	6/2013	Lee et al.	
8,506,458	B2	8/2013	Dugan	
8,515,777	B1	8/2013	Rajasenan	
8,540,515	B2	9/2013	Williams et al.	
8,540,516	B2	9/2013	Williams et al.	
8,556,778	B1	10/2013	Dugan	
8,607,465	B1	12/2013	Edwards	
8,613,689	B2	12/2013	Dyer et al.	
8,615,529	B2	12/2013	Reiner	
8,672,812	B2	3/2014	Dugan	
8,751,264	B2	6/2014	Beraja et al.	
8,784,273	B2	7/2014	Dugan	
8,818,496	B2	8/2014	Dziubinski et al.	
8,823,448	B1	9/2014	Shen	
8,845,493	B2	9/2014	Watterson et al.	
8,849,681	B2	9/2014	Hargrove et al.	
8,864,628	B2	10/2014	Boyette et al.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,893,287 B2 11/2014 Gjonej et al.
8,905,925 B2 12/2014 Beck et al.
8,911,327 B1 12/2014 Boyette
8,979,711 B2 3/2015 Dugan
9,004,598 B2 4/2015 Weber
9,044,630 B1 6/2015 Lampert et al.
9,167,281 B2 10/2015 Petrov et al.
D744,050 S 11/2015 Colburn
9,177,106 B2 11/2015 Smith et al.
9,248,071 B1 2/2016 Brenda
9,256,711 B2 2/2016 Horseman
9,272,091 B2 3/2016 Skelton
9,272,185 B2 3/2016 Dugan
9,283,434 B1 3/2016 Wu
9,295,878 B2 3/2016 Corbalis et al.
9,311,789 B1 4/2016 Gwin
9,312,907 B2 4/2016 Auchinleck et al.
9,367,668 B2 6/2016 Flynt et al.
9,409,054 B2 8/2016 Dugan
9,420,956 B2 8/2016 Gopalakrishnan et al.
9,443,205 B2 9/2016 Wall
9,474,935 B2 10/2016 Abbondanza et al.
9,480,873 B2 11/2016 Chuang
9,481,428 B2 11/2016 Gros
9,514,277 B2 12/2016 Hassing et al.
9,566,472 B2 2/2017 Dugan
9,579,056 B2 2/2017 Rosenbek et al.
9,629,558 B2 4/2017 Yuen et al.
9,640,057 B1 5/2017 Ross
9,707,147 B2 7/2017 Levital et al.
9,713,744 B2 7/2017 Suzuki
D794,142 S 8/2017 Zhou
9,717,947 B2 8/2017 Lin
9,737,761 B1 8/2017 Govindarajan
9,757,612 B2 9/2017 Weber
9,782,621 B2 10/2017 Chiang et al.
9,802,076 B2 10/2017 Murray et al.
9,802,081 B2 10/2017 Ridgel et al.
9,813,239 B2 11/2017 Chee et al.
9,826,908 B2 11/2017 Wu
9,827,445 B2 11/2017 Marcos et al.
9,849,337 B2 12/2017 Roman et al.
9,868,028 B2 1/2018 Shin
9,872,087 B2 1/2018 DelloStritto et al.
9,872,637 B2 1/2018 Kording et al.
9,914,053 B2 3/2018 Dugan
9,919,198 B2 3/2018 Romeo et al.
9,937,382 B2 4/2018 Dugan
9,939,784 B1 4/2018 Berardinelli
9,974,478 B1 5/2018 Brokaw
9,977,587 B2 5/2018 Mountain
9,993,181 B2 6/2018 Ross
9,997,082 B2 6/2018 Kaleal
10,004,946 B2 6/2018 Ross
10,026,052 B2 7/2018 Brown et al.
D826,349 S 8/2018 Oblamski
10,055,550 B2 8/2018 Goetz
10,058,473 B2 8/2018 Oshima et al.
10,074,148 B2 9/2018 Cashman et al.
10,089,443 B2 10/2018 Miller et al.
10,111,643 B2 10/2018 Shulhauser et al.
10,130,311 B1 11/2018 De Sapio et al.
10,137,328 B2 11/2018 Baudhuin
10,143,395 B2 12/2018 Chakravarthy et al.
10,155,134 B2 12/2018 Dugan
10,159,872 B2 12/2018 Sasaki et al.
10,173,094 B2 1/2019 Gomberg et al.
10,173,095 B2 1/2019 Gomberg et al.
10,173,096 B2 1/2019 Gomberg et al.
10,173,097 B2 1/2019 Gomberg et al.
10,182,726 B2 1/2019 Ahmed et al.
10,198,928 B1 2/2019 Ross et al.
10,226,663 B2 3/2019 Gomberg et al.
10,231,664 B2 3/2019 Ganesh
10,244,990 B2 4/2019 Hu et al.
10,258,823 B2 4/2019 Cole
10,322,315 B2 6/2019 Foley et al.
10,325,070 B2 6/2019 Beale et al.
10,327,697 B1 6/2019 Stein et al.
10,362,940 B2 7/2019 Tran
10,369,021 B2 8/2019 Zoss et al.
10,380,866 B1 8/2019 Ross et al.
10,413,222 B1 9/2019 Kayyali
10,413,238 B1 9/2019 Cooper
10,424,033 B2 9/2019 Romeo
10,430,552 B2 10/2019 Mihai
D866,957 S 11/2019 Ross et al.
10,468,131 B2 11/2019 Macoviak et al.
10,475,323 B1 11/2019 Ross
10,475,537 B2 11/2019 Purdie et al.
10,492,977 B2 12/2019 Kapure et al.
10,507,358 B2 12/2019 Kinnunen et al.
10,542,914 B2 1/2020 Forth et al.
10,546,467 B1 1/2020 Luciano, Jr. et al.
10,569,122 B2 2/2020 Johnson
10,572,626 B2 2/2020 Balram
10,576,331 B2 3/2020 Kuo
10,581,896 B2 3/2020 Nachenberg
10,625,114 B2 4/2020 Ercanbrack
10,646,746 B1 5/2020 Gomberg et al.
10,660,534 B2 5/2020 Lee et al.
10,678,890 B2 6/2020 Bitran et al.
10,685,092 B2 6/2020 Paparella et al.
10,741,285 B2 8/2020 Moturu
10,777,200 B2 9/2020 Will et al.
D899,605 S 10/2020 Ross et al.
10,792,495 B2 10/2020 Izvorski et al.
10,814,170 B2 10/2020 Wang et al.
10,857,426 B1 12/2020 Neumann
10,867,695 B2 12/2020 Neagle
10,874,905 B2 12/2020 Belson et al.
D907,143 S 1/2021 Ach et al.
10,881,911 B2 1/2021 Kwon et al.
10,918,332 B2 2/2021 Belson et al.
10,931,643 B1 2/2021 Neumann
10,987,176 B2 4/2021 Poltaretskyi et al.
10,991,463 B2 4/2021 Kutzko et al.
11,000,735 B2 5/2021 Orady et al.
11,045,709 B2 6/2021 Putnam
11,065,170 B2 7/2021 Yang et al.
11,065,527 B2 7/2021 Putnam
11,069,436 B2 7/2021 Mason et al.
11,071,597 B2 7/2021 Posnack et al.
11,075,000 B2 7/2021 Mason et al.
D928,635 S 8/2021 Hacking et al.
11,087,865 B2 8/2021 Mason et al.
11,094,400 B2 8/2021 Riley et al.
11,101,028 B2 8/2021 Mason et al.
11,107,591 B1 8/2021 Mason
11,139,060 B2 10/2021 Mason et al.
11,185,735 B2 11/2021 Arn et al.
11,185,738 B1 11/2021 McKirdy et al.
D939,096 S 12/2021 Lee
D939,644 S 12/2021 Ach et al.
D940,797 S 1/2022 Ach et al.
D940,891 S 1/2022 Lee
11,229,727 B2 1/2022 Tatonetti
11,229,788 B1 1/2022 John
11,265,234 B2 3/2022 Guaneri et al.
11,270,795 B2 3/2022 Mason et al.
11,272,879 B2 3/2022 Wiedenhoefer et al.
11,278,766 B2 3/2022 Lee
11,282,599 B2 3/2022 Mason et al.
11,282,604 B2 3/2022 Mason et al.
11,282,608 B2 3/2022 Mason et al.
11,284,797 B2 3/2022 Mason et al.
D948,639 S 4/2022 Ach et al.
11,295,848 B2 4/2022 Mason et al.
11,298,284 B2 4/2022 Bayerlein
11,309,085 B2 4/2022 Mason et al.
11,317,975 B2 5/2022 Mason et al.
11,325,005 B2 5/2022 Mason et al.
11,328,807 B2 5/2022 Mason et al.
11,337,648 B2 5/2022 Mason

(56) **References Cited**

U.S. PATENT DOCUMENTS

11,347,829	B1	5/2022	Sclar et al.	
11,348,683	B2	5/2022	Guaneri et al.	
11,370,328	B2	6/2022	Main	
11,376,470	B2	7/2022	Weldemariam	
11,404,150	B2	8/2022	Guaneri et al.	
11,410,768	B2	8/2022	Mason et al.	
11,422,841	B2	8/2022	Jeong	
11,437,137	B1	9/2022	Harris	
11,495,355	B2	11/2022	McNutt et al.	
11,508,258	B2	11/2022	Nakashima et al.	
11,524,210	B2	12/2022	Kim et al.	
11,527,326	B2	12/2022	McNair et al.	
11,532,402	B2	12/2022	Farley et al.	
11,534,654	B2	12/2022	Silcock et al.	
D976,339	S	1/2023	Li	
11,553,969	B1	1/2023	Lang et al.	
11,621,067	B1	4/2023	Nolan	
11,636,944	B2	4/2023	Hanrahan et al.	
11,654,327	B2	5/2023	Phillips et al.	
11,663,673	B2	5/2023	Pyles	
11,673,024	B2	6/2023	Omid-Zohoor	
11,701,548	B2	7/2023	Posnack et al.	
11,776,676	B2	10/2023	Savolainen	
11,944,579	B2	4/2024	Sankai	
11,957,960	B2	4/2024	Bissonnette et al.	
12,004,871	B1	6/2024	Fazeli	
12,057,210	B2	8/2024	Akinola et al.	
12,205,704	B2	1/2025	Hosoi et al.	
2001/0044573	A1	11/2001	Manoli	
2002/0010596	A1	1/2002	Matory	
2002/0072452	A1	6/2002	Torkelson	
2002/0143279	A1	10/2002	Porter et al.	
2002/0160883	A1	10/2002	Dugan	
2002/0183599	A1	12/2002	Castellanos	
2003/0013072	A1	1/2003	Thomas	
2003/0036683	A1	2/2003	Kehr et al.	
2003/0064860	A1	4/2003	Yamashita et al.	
2003/0064863	A1	4/2003	Chen	
2003/0083596	A1	5/2003	Kramer et al.	
2003/0092536	A1	5/2003	Romanelli et al.	
2003/0181832	A1	9/2003	Carnahan et al.	
2004/0072652	A1	4/2004	Alessandri et al.	
2004/0102931	A1	5/2004	Ellis et al.	
2004/0106502	A1	6/2004	Sher	
2004/0147969	A1	7/2004	Mann et al.	
2004/0172093	A1	9/2004	Rummerfield	
2004/0194572	A1	10/2004	Kim	
2004/0197727	A1	10/2004	Sachdeva et al.	
2004/0204959	A1	10/2004	Moreano et al.	
2005/0015118	A1	1/2005	Davis et al.	
2005/0020411	A1	1/2005	Andrews	
2005/0043153	A1	2/2005	Krietzman	
2005/0049122	A1	3/2005	Vallone et al.	
2005/0085346	A1	4/2005	Johnson	
2005/0085353	A1	4/2005	Johnson	
2005/0115561	A1	6/2005	Stahmann	
2005/0143641	A1	6/2005	Tashiro	
2005/0274220	A1	12/2005	Reboullet	
2006/0003871	A1	1/2006	Houghton et al.	
2006/0046905	A1	3/2006	Doody et al.	
2006/0058648	A1	3/2006	Meier	
2006/0064136	A1	3/2006	Wang	
2006/0064329	A1	3/2006	Abolfathi et al.	
2006/0129432	A1	6/2006	Choi et al.	
2006/0199700	A1	9/2006	LaStayo et al.	
2006/0247095	A1	11/2006	Rummerfield	
2006/0277074	A1	12/2006	Einav	
2007/0042868	A1	2/2007	Fisher et al.	
2007/0118389	A1	5/2007	Shipon	
2007/0137307	A1	6/2007	Gruben et al.	
2007/0173392	A1	7/2007	Stanford	
2007/0184414	A1	8/2007	Perez	
2007/0194939	A1	8/2007	Alvarez et al.	
2007/0219059	A1	9/2007	Schwartz	
2007/0271065	A1	11/2007	Gupta et al.	
2007/0287597	A1	12/2007	Cameron	
2008/0021834	A1	1/2008	Holla et al.	
2008/0077619	A1	3/2008	Gilley et al.	
2008/0082356	A1	4/2008	Friedlander et al.	
2008/0096726	A1*	4/2008	Riley	A63B 24/0087 482/8
2008/0153592	A1	6/2008	James-Herbert	
2008/0161166	A1	7/2008	Lo	
2008/0161733	A1	7/2008	Einav et al.	
2008/0183500	A1	7/2008	Banigan	
2008/0281633	A1	11/2008	Burdea et al.	
2008/0300914	A1	12/2008	Karkanias et al.	
2008/0312040	A1*	12/2008	Ochi	A63B 23/0405 600/587
2009/0011907	A1	1/2009	Radow et al.	
2009/0037334	A1	2/2009	Hsu	
2009/0058635	A1	3/2009	LaLonde et al.	
2009/0070138	A1	3/2009	Langheier et al.	
2009/0211395	A1	8/2009	Mule	
2009/0270227	A1	10/2009	Ashby et al.	
2009/0287503	A1	11/2009	Angell et al.	
2009/0299766	A1	12/2009	Friedlander et al.	
2010/0048358	A1	2/2010	Tchao et al.	
2010/0062818	A1	3/2010	Haughay, Jr.	
2010/0076786	A1	3/2010	Dalton et al.	
2010/0121160	A1	5/2010	Stark et al.	
2010/0173747	A1	7/2010	Chen et al.	
2010/0216168	A1	8/2010	Heinzman et al.	
2010/0234184	A1	9/2010	Le Page et al.	
2010/0248899	A1	9/2010	Bedell et al.	
2010/0248905	A1	9/2010	Lu	
2010/0262052	A1	10/2010	Lunau et al.	
2010/0268304	A1	10/2010	Matos	
2010/0298102	A1	11/2010	Bosecker et al.	
2010/0326207	A1	12/2010	Topel	
2011/0010188	A1	1/2011	Yoshikawa et al.	
2011/0047108	A1	2/2011	Chakrabarty et al.	
2011/0082007	A1	4/2011	Birrell	
2011/0087137	A1	4/2011	Hanoun	
2011/0119212	A1	5/2011	De Bruin et al.	
2011/0172059	A1	7/2011	Watterson et al.	
2011/0195819	A1	8/2011	Shaw et al.	
2011/0218814	A1	9/2011	Coats	
2011/0275483	A1	11/2011	Dugan	
2011/0281249	A1	11/2011	Gammell et al.	
2011/0306846	A1	12/2011	Osorio	
2012/0041771	A1	2/2012	Cosentino et al.	
2012/0065987	A1	3/2012	Farooq et al.	
2012/0116258	A1	5/2012	Lee	
2012/0130196	A1	5/2012	Jain et al.	
2012/0130197	A1	5/2012	Kugler et al.	
2012/0167709	A1	7/2012	Chen et al.	
2012/0183939	A1	7/2012	Aragones et al.	
2012/0190502	A1	7/2012	Paulus et al.	
2012/0232438	A1	9/2012	Cataldi et al.	
2012/0259648	A1	10/2012	Mallon et al.	
2012/0259649	A1	10/2012	Mallon et al.	
2012/0278759	A1	11/2012	Curl et al.	
2012/0295240	A1	11/2012	Walker et al.	
2012/0296455	A1	11/2012	Ohnemus et al.	
2012/0310667	A1	12/2012	Altman et al.	
2013/0066647	A1	3/2013	Andrie	
2013/0108594	A1	5/2013	Martin-Rendon et al.	
2013/0110545	A1	5/2013	Smallwood	
2013/0123071	A1	5/2013	Rhea	
2013/0123667	A1	5/2013	Komatireddy et al.	
2013/0137550	A1	5/2013	Skinner et al.	
2013/0137552	A1	5/2013	Kemp et al.	
2013/0158368	A1	6/2013	Pacione	
2013/0165195	A1	6/2013	Watterson	
2013/0178334	A1	7/2013	Brammer	
2013/0211281	A1	8/2013	Ross et al.	
2013/0253943	A1	9/2013	Lee et al.	
2013/0274069	A1	10/2013	Watterson et al.	
2013/0296987	A1	11/2013	Rogers et al.	
2013/0318027	A1	11/2013	Almogy et al.	
2013/0332616	A1	12/2013	Landwehr	
2013/0345025	A1	12/2013	van der Merwe	
2014/0006042	A1	1/2014	Keefe et al.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

2014/0011640 A1 1/2014 Dugan
2014/0031174 A1 1/2014 Huang
2014/0062900 A1 3/2014 Kaula et al.
2014/0073486 A1 3/2014 Ahmed et al.
2014/0074179 A1 3/2014 Heldman et al.
2014/0089836 A1 3/2014 Damani et al.
2014/0108035 A1 4/2014 Akbay
2014/0113261 A1* 4/2014 Akiba G09B 19/00 434/247
2014/0113768 A1 4/2014 Lin et al.
2014/0135173 A1 5/2014 Watterson
2014/0155129 A1 6/2014 Dugan
2014/0163439 A1 6/2014 Uryash et al.
2014/0172442 A1 6/2014 Broderick
2014/0172460 A1 6/2014 Kohli
2014/0172514 A1 6/2014 Schumann et al.
2014/0188009 A1 7/2014 Lange et al.
2014/0194250 A1 7/2014 Reich et al.
2014/0194251 A1 7/2014 Reich et al.
2014/0200414 A1 7/2014 Osorio
2014/0207264 A1 7/2014 Quy
2014/0207486 A1 7/2014 Carty et al.
2014/0228649 A1 8/2014 Rayner et al.
2014/0246499 A1 9/2014 Proud et al.
2014/0256511 A1 9/2014 Smith
2014/0257837 A1 9/2014 Walker et al.
2014/0274565 A1 9/2014 Boyette et al.
2014/0274622 A1 9/2014 Leonhard
2014/0303540 A1 10/2014 Baym
2014/0309083 A1 10/2014 Dugan
2014/0322686 A1 10/2014 Kang
2014/0347265 A1 11/2014 Aimone et al.
2014/0371816 A1 12/2014 Matos
2014/0372133 A1 12/2014 Austrum et al.
2015/0025816 A1 1/2015 Ross
2015/0045700 A1 2/2015 Cavanagh et al.
2015/0046192 A1 2/2015 Raduchel
2015/0051721 A1 2/2015 Cheng
2015/0065213 A1 3/2015 Dugan
2015/0073814 A1 3/2015 Linebaugh
2015/0088544 A1 3/2015 Goldberg
2015/0094192 A1 4/2015 Skwortsow et al.
2015/0099458 A1 4/2015 Weisner et al.
2015/0099952 A1 4/2015 Lain et al.
2015/0111644 A1 4/2015 Larson
2015/0112230 A1 4/2015 Iglesias
2015/0112702 A1 4/2015 Joao et al.
2015/0130830 A1 5/2015 Nagasaki
2015/0141200 A1 5/2015 Murray et al.
2015/0142142 A1 5/2015 Aguilera et al.
2015/0149217 A1 5/2015 Kaburagi
2015/0151162 A1 6/2015 Dugan
2015/0157938 A1 6/2015 Domansky et al.
2015/0161331 A1 6/2015 Oleynik
2015/0161876 A1 6/2015 Castillo
2015/0174446 A1 6/2015 Chiang
2015/0196804 A1 7/2015 Koduri
2015/0196805 A1 7/2015 Koduri
2015/0199494 A1 7/2015 Koduri
2015/0217056 A1 8/2015 Kadavy et al.
2015/0251074 A1 9/2015 Ahmed et al.
2015/0257679 A1 9/2015 Ross
2015/0265209 A1 9/2015 Zhang
2015/0290061 A1 10/2015 Stafford et al.
2015/0331997 A1 11/2015 Joao
2015/0335950 A1 11/2015 Eder
2015/0335951 A1 11/2015 Eder
2015/0339442 A1 11/2015 Oleynik
2015/0341812 A1 11/2015 Dion et al.
2015/0351664 A1 12/2015 Ross
2015/0351665 A1 12/2015 Ross
2015/0360069 A1 12/2015 Marti et al.
2015/0379232 A1 12/2015 Mainwaring et al.
2015/0379430 A1 12/2015 Dirac et al.
2016/0004820 A1 1/2016 Moore
2016/0007885 A1 1/2016 Basta
2016/0015995 A1 1/2016 Leung et al.
2016/0023081 A1 1/2016 Popa-Simil et al.
2016/0045170 A1 2/2016 Migita
2016/0086500 A1 3/2016 Kaleal, III
2016/0096073 A1 4/2016 Rahman et al.
2016/0117471 A1 4/2016 Belt et al.
2016/0132643 A1 5/2016 Radhakrishna et al.
2016/0140319 A1 5/2016 Stark
2016/0143593 A1 5/2016 Fu et al.
2016/0151670 A1 6/2016 Dugan
2016/0158534 A1 6/2016 Guarraia et al.
2016/0166833 A1 6/2016 Bum
2016/0166881 A1 6/2016 Ridgel et al.
2016/0193306 A1 7/2016 Rabovsky et al.
2016/0197918 A1 7/2016 Turgeman et al.
2016/0213924 A1 7/2016 Coleman
2016/0250519 A1 9/2016 Watterson
2016/0275259 A1 9/2016 Nolan et al.
2016/0287166 A1 10/2016 Tran
2016/0302666 A1 10/2016 Shaya
2016/0302721 A1 10/2016 Wiedenhoefer et al.
2016/0317869 A1 11/2016 Dugan
2016/0322078 A1 11/2016 Bose et al.
2016/0325140 A1 11/2016 Wu
2016/0332028 A1 11/2016 Melnik
2016/0345841 A1 12/2016 Jang et al.
2016/0354636 A1 12/2016 Jang
2016/0361025 A1 12/2016 Reicher et al.
2016/0361597 A1* 12/2016 Cole A63B 23/03583
2016/0373477 A1 12/2016 Moyle
2017/0004260 A1 1/2017 Moturu et al.
2017/0011179 A1 1/2017 Arshad et al.
2017/0032092 A1 2/2017 Mink et al.
2017/0033375 A1 2/2017 Ohmori et al.
2017/0042467 A1 2/2017 Herr et al.
2017/0046488 A1 2/2017 Pereira
2017/0065851 A1 3/2017 Deluca et al.
2017/0080320 A1 3/2017 Smith
2017/0091422 A1 3/2017 Kumar et al.
2017/0095670 A1 4/2017 Ghaffari et al.
2017/0095692 A1 4/2017 Chang et al.
2017/0095693 A1 4/2017 Chang et al.
2017/0100637 A1 4/2017 Princen et al.
2017/0106242 A1 4/2017 Dugan
2017/0113092 A1 4/2017 Johnson
2017/0128769 A1 5/2017 Long et al.
2017/0132947 A1* 5/2017 Maeda G05G 9/047
2017/0136296 A1 5/2017 Barrera et al.
2017/0136298 A1 5/2017 Bae
2017/0143261 A1 5/2017 Wiedenhoefer et al.
2017/0147752 A1 5/2017 Toru
2017/0147789 A1 5/2017 Wiedenhoefer et al.
2017/0148297 A1 5/2017 Ross
2017/0168555 A1 6/2017 Munoz et al.
2017/0181698 A1 6/2017 Wiedenhoefer et al.
2017/0190052 A1 7/2017 Jaekel et al.
2017/0202724 A1 7/2017 De Rossi
2017/0209766 A1 7/2017 Riley et al.
2017/0220751 A1 8/2017 Davis
2017/0228517 A1 8/2017 Saliman et al.
2017/0235882 A1 8/2017 Orlov et al.
2017/0235906 A1 8/2017 Dorris et al.
2017/0243028 A1 8/2017 LaFever et al.
2017/0258370 A1 9/2017 Plotnik-Peleg et al.
2017/0262604 A1 9/2017 Francois
2017/0265800 A1 9/2017 Auchinleck et al.
2017/0266501 A1 9/2017 Sanders et al.
2017/0270260 A1 9/2017 Shetty
2017/0278209 A1 9/2017 Olsen et al.
2017/0282015 A1 10/2017 Wicks et al.
2017/0283508 A1 10/2017 Demopulos et al.
2017/0286621 A1 10/2017 Cox
2017/0296861 A1 10/2017 Burkinshaw
2017/0300654 A1 10/2017 Stein et al.
2017/0304024 A1 10/2017 Nobrega
2017/0312614 A1 11/2017 Tran et al.
2017/0323481 A1 11/2017 Tran et al.
2017/0329917 A1 11/2017 McRaith et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2017/0329933 A1 11/2017 Brust
2017/0333755 A1 11/2017 Rider
2017/0337033 A1 11/2017 Duyan et al.
2017/0337334 A1 11/2017 Stanczak
2017/0344726 A1 11/2017 Duffy et al.
2017/0347923 A1 12/2017 Roh
2017/0360586 A1 12/2017 Dempers et al.
2017/0368413 A1 12/2017 Shavit
2018/0017806 A1 1/2018 Wang et al.
2018/0036591 A1 2/2018 King et al.
2018/0036593 A1 2/2018 Ridgel et al.
2018/0052962 A1 2/2018 Van Der Koijk et al.
2018/0056104 A1 3/2018 Cromie et al.
2018/0056130 A1 3/2018 Bitran et al.
2018/0060494 A1 3/2018 Dias et al.
2018/0070864 A1 3/2018 Schuster
2018/0071565 A1 3/2018 Gomberg et al.
2018/0071566 A1 3/2018 Gomberg et al.
2018/0071569 A1 3/2018 Gomberg et al.
2018/0071570 A1 3/2018 Gomberg et al.
2018/0071571 A1 3/2018 Gomberg et al.
2018/0071572 A1 3/2018 Gomberg et al.
2018/0075205 A1 3/2018 Moturu et al.
2018/0078843 A1 3/2018 Tran et al.
2018/0085615 A1 3/2018 Astolfi et al.
2018/0089385 A1 3/2018 Gupta
2018/0096111 A1 4/2018 Wells et al.
2018/0099178 A1 4/2018 Schaefer et al.
2018/0102190 A1 4/2018 Hogue et al.
2018/0103859 A1 4/2018 Provenzano
2018/0113985 A1 4/2018 Gandy et al.
2018/0116741 A1 5/2018 Garcia Kilroy et al.
2018/0117417 A1 5/2018 Davis
2018/0130555 A1 5/2018 Chronis et al.
2018/0140927 A1 5/2018 Kito
2018/0146870 A1 5/2018 Shemesh
2018/0177612 A1 6/2018 Trabish et al.
2018/0178061 A1 6/2018 O'Larte et al.
2018/0199855 A1 7/2018 Odame et al.
2018/0200577 A1 7/2018 Dugan
2018/0220935 A1 8/2018 Tadano et al.
2018/0228682 A1 8/2018 Bayerlein et al.
2018/0232492 A1 8/2018 Al-Alul et al.
2018/0236307 A1 8/2018 Hyde et al.
2018/0240552 A1 8/2018 Tuyl et al.
2018/0253991 A1 9/2018 Tang et al.
2018/0255110 A1 9/2018 Dowlatkhah et al.
2018/0256079 A1 9/2018 Yang et al.
2018/0263530 A1 9/2018 Jung
2018/0263535 A1 9/2018 Cramer
2018/0263552 A1 9/2018 Graman et al.
2018/0264312 A1 9/2018 Pompile et al.
2018/0271432 A1 9/2018 Auchinleck et al.
2018/0272184 A1 9/2018 Vassilaros et al.
2018/0280784 A1 10/2018 Romeo et al.
2018/0290017 A1 10/2018 Fung
2018/0296143 A1 10/2018 Anderson et al.
2018/0296157 A1 10/2018 Bleich et al.
2018/0318122 A1 11/2018 LeCursi et al.
2018/0326243 A1 11/2018 Badi et al.
2018/0330058 A1 11/2018 Bates
2018/0330810 A1 11/2018 Gamarnik
2018/0330824 A1 11/2018 Athey et al.
2018/0353812 A1 12/2018 Lannon et al.
2018/0360340 A1 12/2018 Rehse et al.
2018/0366225 A1 12/2018 Mansi et al.
2018/0373844 A1 12/2018 Ferrandez-Escamez et al.
2019/0005195 A1 1/2019 Peterson
2019/0009135 A1 1/2019 Wu
2019/0019163 A1 1/2019 Batey et al.
2019/0019573 A1 1/2019 Lake et al.
2019/0019578 A1 1/2019 Vaccaro
2019/0030415 A1 1/2019 Volpe, Jr.
2019/0031284 A1 1/2019 Fuchs
2019/0046794 A1 2/2019 Goodall et al.
2019/0060708 A1 2/2019 Fung
2019/0065970 A1 2/2019 Bonutti et al.
2019/0066832 A1* 2/2019 Kang A61B 5/1128
2019/0076701 A1 3/2019 Dugan
2019/0080802 A1 3/2019 Ziobro et al.
2019/0083846 A1 3/2019 Eder
2019/0088356 A1 3/2019 Oliver et al.
2019/0090744 A1 3/2019 Mahfouz
2019/0096534 A1 3/2019 Joao
2019/0105551 A1 4/2019 Ray
2019/0108912 A1 4/2019 Spurlock, III
2019/0111299 A1* 4/2019 Radcliffe A61H 1/0274
2019/0115097 A1 4/2019 Macoviak et al.
2019/0117156 A1 4/2019 Howard et al.
2019/0118038 A1 4/2019 Tana et al.
2019/0118066 A1 4/2019 Cardona
2019/0126099 A1 5/2019 Hoang
2019/0132948 A1 5/2019 Longinotti-Buitoni et al.
2019/0134454 A1 5/2019 Mahoney et al.
2019/0137988 A1 5/2019 Cella et al.
2019/0143191 A1 5/2019 Ran et al.
2019/0143193 A1 5/2019 Kim
2019/0145774 A1 5/2019 Ellis
2019/0163876 A1 5/2019 Remme et al.
2019/0167988 A1 6/2019 Shahriari et al.
2019/0172587 A1 6/2019 Park et al.
2019/0175988 A1 6/2019 Volterrani et al.
2019/0183715 A1 6/2019 Kapure et al.
2019/0200920 A1 7/2019 Tien et al.
2019/0209891 A1 7/2019 Fung
2019/0214119 A1 7/2019 Wachira et al.
2019/0223797 A1 7/2019 Tran
2019/0224528 A1 7/2019 Omid-Zohoor et al.
2019/0228856 A1 7/2019 Leifer
2019/0232108 A1 8/2019 Kovach et al.
2019/0240103 A1 8/2019 Hepler et al.
2019/0240541 A1 8/2019 Denton et al.
2019/0244540 A1 8/2019 Errante et al.
2019/0247718 A1 8/2019 Blevins
2019/0251456 A1 8/2019 Constantin
2019/0261959 A1 8/2019 Frankel
2019/0262084 A1 8/2019 Roh
2019/0269343 A1 9/2019 Ramos Murguialday et al.
2019/0274523 A1 9/2019 Bates et al.
2019/0275368 A1 9/2019 Maroldi
2019/0283247 A1 9/2019 Chang
2019/0304584 A1 10/2019 Savolainen
2019/0307983 A1 10/2019 Goldman
2019/0314681 A1 10/2019 Yang
2019/0344123 A1 11/2019 Rubin et al.
2019/0354632 A1 11/2019 Mital et al.
2019/0362242 A1 11/2019 Pillai et al.
2019/0366146 A1 12/2019 Tong et al.
2019/0371472 A1 12/2019 Blanchard
2019/0385199 A1 12/2019 Bender et al.
2019/0388728 A1 12/2019 Wang et al.
2019/0392936 A1 12/2019 Arric et al.
2019/0392939 A1 12/2019 Basta et al.
2020/0005928 A1 1/2020 Daniel
2020/0034665 A1 1/2020 Ghanta
2020/0034707 A1 1/2020 Kivatinos et al.
2020/0038703 A1 2/2020 Cleary et al.
2020/0051446 A1 2/2020 Rubinstein
2020/0054922 A1 2/2020 Azaria
2020/0066390 A1* 2/2020 Svendrys G06F 3/0346
2020/0085300 A1 3/2020 Kwatra et al.
2020/0090802 A1 3/2020 Maron
2020/0093418 A1 3/2020 Kluger et al.
2020/0121987 A1 4/2020 Loh
2020/0129808 A1 4/2020 Fomin
2020/0139194 A1 5/2020 Min
2020/0143922 A1 5/2020 Chekroud et al.
2020/0151595 A1 5/2020 Jayalath et al.
2020/0151646 A1 5/2020 De La Fuente Sanchez
2020/0152339 A1 5/2020 Pulitzer et al.
2020/0160198 A1 5/2020 Reeves et al.
2020/0170876 A1 6/2020 Kapure et al.
2020/0176098 A1 6/2020 Lucas et al.
2020/0188774 A1 6/2020 Fung

(56) **References Cited**

U.S. PATENT DOCUMENTS

2020/0197744 A1 6/2020 Schweighofer
2020/0221975 A1 7/2020 Basta et al.
2020/0237291 A1 7/2020 Raja
2020/0237452 A1 7/2020 Wolf et al.
2020/0261763 A1 8/2020 Park
2020/0267487 A1 8/2020 Siva
2020/0275886 A1 9/2020 Mason
2020/0289045 A1 9/2020 Hacking et al.
2020/0289046 A1 9/2020 Hacking et al.
2020/0289879 A1 9/2020 Hacking et al.
2020/0289880 A1 9/2020 Hacking et al.
2020/0289881 A1 9/2020 Hacking et al.
2020/0289889 A1 9/2020 Hacking et al.
2020/0293712 A1 9/2020 Potts et al.
2020/0303063 A1 9/2020 Sharma et al.
2020/0312447 A1 10/2020 Bohn et al.
2020/0320454 A1 10/2020 Almashor
2020/0334972 A1 10/2020 Gopalakrishnan
2020/0353314 A1 11/2020 Messinger
2020/0357299 A1 11/2020 Patel et al.
2020/0365256 A1 11/2020 Hayashitani et al.
2020/0391080 A1 12/2020 Powers
2020/0395112 A1 12/2020 Ronner
2020/0398083 A1 12/2020 Adelsheim
2020/0401224 A1 12/2020 Cotton
2020/0402662 A1 12/2020 Esmailian et al.
2020/0410374 A1 12/2020 White
2020/0410385 A1 12/2020 Otsuki
2020/0411162 A1 12/2020 Lien et al.
2020/0411170 A1 12/2020 Brown
2021/0005224 A1 1/2021 Rothschild et al.
2021/0005319 A1 1/2021 Otsuki et al.
2021/0008413 A1 1/2021 Asikainen et al.
2021/0015560 A1 1/2021 Boddington et al.
2021/0027889 A1 1/2021 Neil et al.
2021/0035674 A1 2/2021 Volosin et al.
2021/0050086 A1 2/2021 Rose et al.
2021/0065855 A1 3/2021 Pepin et al.
2021/0074178 A1 3/2021 Tlan et al.
2021/0076981 A1 3/2021 Hacking et al.
2021/0077860 A1 3/2021 Posnack et al.
2021/0077884 A1 3/2021 De Las Casas Zolezzi et al.
2021/0082554 A1 3/2021 Kalia et al.
2021/0093891 A1 4/2021 Sheng
2021/0098099 A1 4/2021 Neumann
2021/0098129 A1 4/2021 Neumann
2021/0101051 A1 4/2021 Posnack et al.
2021/0113890 A1 4/2021 Posnack et al.
2021/0125696 A1 4/2021 Liu et al.
2021/0127974 A1 5/2021 Mason et al.
2021/0128080 A1 5/2021 Mason et al.
2021/0128255 A1 5/2021 Mason et al.
2021/0128978 A1 5/2021 Gilstrom et al.
2021/0134412 A1 5/2021 Guaneri et al.
2021/0134425 A1 5/2021 Mason et al.
2021/0134428 A1 5/2021 Mason
2021/0134430 A1 5/2021 Mason et al.
2021/0134432 A1 5/2021 Mason et al.
2021/0134456 A1 5/2021 Posnack et al.
2021/0134457 A1 5/2021 Mason et al.
2021/0134458 A1 5/2021 Mason et al.
2021/0134463 A1 5/2021 Mason et al.
2021/0138304 A1 5/2021 Mason et al.
2021/0142875 A1 5/2021 Mason et al.
2021/0142893 A1 5/2021 Guaneri et al.
2021/0142898 A1 5/2021 Mason et al.
2021/0142903 A1 5/2021 Mason et al.
2021/0144074 A1 5/2021 Guaneri et al.
2021/0186419 A1 6/2021 Van Ee et al.
2021/0187348 A1 6/2021 Phillips et al.
2021/0202090 A1 7/2021 ODonovan et al.
2021/0202103 A1 7/2021 Bostic et al.
2021/0205660 A1 7/2021 Shavit
2021/0236020 A1 8/2021 Matijevich et al.
2021/0240853 A1 8/2021 Carlson
2021/0244998 A1 8/2021 Hacking et al.
2021/0245003 A1 8/2021 Turner
2021/0251562 A1 8/2021 Jain
2021/0272677 A1 9/2021 Barbee
2021/0338469 A1 11/2021 Dempers
2021/0343384 A1 11/2021 Purushothaman et al.
2021/0345879 A1 11/2021 Mason et al.
2021/0345975 A1 11/2021 Mason et al.
2021/0350888 A1 11/2021 Guaneri et al.
2021/0350898 A1 11/2021 Mason et al.
2021/0350899 A1 11/2021 Mason et al.
2021/0350901 A1 11/2021 Mason et al.
2021/0350902 A1 11/2021 Mason et al.
2021/0350914 A1 11/2021 Guaneri et al.
2021/0350926 A1 11/2021 Mason et al.
2021/0354002 A1 11/2021 Schaefer
2021/0361514 A1 11/2021 Choi et al.
2021/0366587 A1 11/2021 Mason et al.
2021/0375425 A1 12/2021 Zhang
2021/0383909 A1 12/2021 Mason et al.
2021/0391091 A1 12/2021 Mason
2021/0398668 A1 12/2021 Chock et al.
2021/0407670 A1 12/2021 Mason et al.
2021/0407681 A1 12/2021 Mason et al.
2022/0000556 A1 1/2022 Casey et al.
2022/0015838 A1 1/2022 Posnack
2022/0016480 A1 1/2022 Bissonnette et al.
2022/0016482 A1 1/2022 Bissonnette
2022/0016485 A1 1/2022 Bissonnette
2022/0016486 A1 1/2022 Bissonnette
2022/0020469 A1 1/2022 Tanner
2022/0044806 A1 2/2022 Sanders et al.
2022/0047921 A1 2/2022 Bissonnette
2022/0066548 A1 3/2022 Helot
2022/0079690 A1 3/2022 Mason et al.
2022/0080256 A1 3/2022 Arn et al.
2022/0080265 A1 3/2022 Watterson
2022/0105384 A1 4/2022 Hacking et al.
2022/0105385 A1 4/2022 Hacking et al.
2022/0105390 A1 4/2022 Yuasa
2022/0115133 A1 4/2022 Mason et al.
2022/0118218 A1 4/2022 Bense et al.
2022/0122724 A1 4/2022 Durlach et al.
2022/0126169 A1 4/2022 Mason
2022/0133576 A1 5/2022 Choi et al.
2022/0148725 A1 5/2022 Mason et al.
2022/0158916 A1 5/2022 Mason et al.
2022/0176039 A1 6/2022 Lintereur et al.
2022/0181004 A1 6/2022 Zilca et al.
2022/0193491 A1 6/2022 Mason
2022/0230729 A1 7/2022 Mason
2022/0238222 A1 7/2022 Neuberg
2022/0238223 A1 7/2022 Mason
2022/0258935 A1 8/2022 Kraft
2022/0262483 A1 8/2022 Rosenberg et al.
2022/0262504 A1 8/2022 Bratty et al.
2022/0266094 A1 8/2022 Mason et al.
2022/0270738 A1 8/2022 Mason et al.
2022/0273985 A1 9/2022 Jeong et al.
2022/0273986 A1 9/2022 Mason
2022/0288460 A1 9/2022 Mason
2022/0288461 A1 9/2022 Ashley et al.
2022/0288462 A1 9/2022 Ashley et al.
2022/0293257 A1 9/2022 Guaneri et al.
2022/0300787 A1 9/2022 Wall et al.
2022/0304881 A1 9/2022 Choi et al.
2022/0304882 A1 9/2022 Choi
2022/0305328 A1 9/2022 Choi et al.
2022/0314072 A1 10/2022 Bissonnette et al.
2022/0314075 A1 10/2022 Mason et al.
2022/0323826 A1 10/2022 Khurana
2022/0327714 A1 10/2022 Cook et al.
2022/0327807 A1 10/2022 Cook et al.
2022/0328181 A1 10/2022 Mason et al.
2022/0330823 A1 10/2022 Janssen
2022/0331663 A1 10/2022 Mason
2022/0338761 A1 10/2022 Maddahi et al.
2022/0339052 A1 10/2022 Kim
2022/0339501 A1 10/2022 Mason et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2022/0370851	A1	11/2022	Guidarelli et al.
2022/0384010	A1	12/2022	Kanayama
2022/0384012	A1	12/2022	Mason
2022/0392591	A1	12/2022	Guaneri et al.
2022/0395232	A1	12/2022	Locke
2022/0401783	A1	12/2022	Choi
2022/0415469	A1	12/2022	Mason
2022/0415471	A1	12/2022	Mason
2023/0001268	A1	1/2023	Bissonnette et al.
2023/0013530	A1	1/2023	Mason
2023/0014598	A1	1/2023	Mason et al.
2023/0029639	A1	2/2023	Roy
2023/0047253	A1	2/2023	Gnanasambandam et al.
2023/0048040	A1	2/2023	Hacking et al.
2023/0051751	A1	2/2023	Hacking et al.
2023/0058605	A1	2/2023	Mason
2023/0060039	A1	2/2023	Mason
2023/0072368	A1	3/2023	Mason
2023/0078793	A1	3/2023	Mason
2023/0119461	A1	4/2023	Mason
2023/0190100	A1	6/2023	Stump
2023/0197240	A1	6/2023	Rosenberg
2023/0201656	A1	6/2023	Hacking et al.
2023/0207097	A1	6/2023	Mason
2023/0207124	A1	6/2023	Walsh et al.
2023/0215539	A1	7/2023	Rosenberg et al.
2023/0215552	A1	7/2023	Khotilovich et al.
2023/0218950	A1	7/2023	Belson et al.
2023/0245747	A1	8/2023	Rosenberg et al.
2023/0245748	A1	8/2023	Rosenberg et al.
2023/0245750	A1	8/2023	Rosenberg et al.
2023/0245751	A1	8/2023	Rosenberg et al.
2023/0249599	A1	8/2023	Nicola
2023/0253089	A1	8/2023	Rosenberg et al.
2023/0255555	A1	8/2023	Sundaram et al.
2023/0263428	A1	8/2023	Hull et al.
2023/0274813	A1	8/2023	Rosenberg et al.
2023/0282329	A1	9/2023	Mason et al.
2023/0364472	A1	11/2023	Posnack
2023/0368886	A1	11/2023	Rosenberg
2023/0377710	A1	11/2023	Chen et al.
2023/0377711	A1	11/2023	Rosenberg
2023/0377712	A1	11/2023	Rosenberg
2023/0386639	A1	11/2023	Rosenberg
2023/0395231	A1	12/2023	Rosenberg
2023/0395232	A1	12/2023	Rosenberg
2024/0029856	A1	1/2024	Rosenberg
2024/0058651	A1	2/2024	Bissonnette
2024/0177846	A1	5/2024	Gnanasambandam
2024/0203580	A1	6/2024	Mason

FOREIGN PATENT DOCUMENTS

CN	101964151	A	2/2011	
CN	201889024	U	7/2011	
CN	202220794	U	5/2012	
CN	102670381	A	9/2012	
CN	103263336	A	8/2013	
CN	103390357	A	11/2013	
CN	103473631	A	12/2013	
CN	103488880	A	1/2014	
CN	103501328	A	1/2014	
CN	103721343	A	4/2014	
CN	203677851	U	7/2014	
CN	104335211	A	2/2015	
CN	105263448	A *	1/2016	..... A61B 5/112
CN	105620643	A	6/2016	
CN	105683977	A	6/2016	
CN	103136447	B	8/2016	
CN	105894088	A	8/2016	
CN	105930668	A	9/2016	
CN	205626871	U	10/2016	
CN	106127646	A	11/2016	
CN	106236502	A	12/2016	
CN	106510985	A	3/2017	
CN	106621195	A	5/2017	
CN	107025373	A	8/2017	
CN	107066819	A	8/2017	
CN	107430641	A	12/2017	
CN	107551475	A	1/2018	
CN	107736982	A	2/2018	
CN	107930021	A	4/2018	
CN	108078737	A	5/2018	
CN	207429102	U	6/2018	
CN	208224811	A	12/2018	
CN	109191954	A	1/2019	
CN	109248432	A	1/2019	
CN	109308940	A	2/2019	
CN	109363887	A	2/2019	
CN	109431742	A	3/2019	
CN	208573971	U	3/2019	
CN	110148472	A	8/2019	
CN	110201358	A	9/2019	
CN	110215188	A	9/2019	
CN	110322957	A	10/2019	
CN	110613585	A	12/2019	
CN	110721438	A	1/2020	
CN	110808092	A	2/2020	
CN	110931103	A	3/2020	
CN	110993057	A	4/2020	
CN	210384372	U	4/2020	
CN	111084618	A	5/2020	
CN	111105859	A	5/2020	
CN	111111110	A	5/2020	
CN	111199787	A	5/2020	
CN	210447971	U	5/2020	
CN	111329674	A	6/2020	
CN	111370088	A	7/2020	
CN	111460305	A	7/2020	
CN	111544834	A	8/2020	
CN	111714832	A	9/2020	
CN	111790111	A	10/2020	
CN	211635070	U	10/2020	
CN	211798556	U	10/2020	
CN	111973956	A	11/2020	
CN	112071393	A	12/2020	
CN	212067582	U	12/2020	
CN	212141371	U	12/2020	
CN	112190440	A	1/2021	
CN	112289425	A	1/2021	
CN	212522890	U	2/2021	
CN	212624809	U	2/2021	
CN	212730865	U	3/2021	
CN	112603295	A	4/2021	
CN	213049207	U	4/2021	
CN	213077324	U	4/2021	
CN	213190965	U	5/2021	
CN	213220742	U	5/2021	
CN	213823322	U	7/2021	
CN	213851851	U	8/2021	
CN	213994716	U	8/2021	
CN	113384850	A	9/2021	
CN	113421642	A	9/2021	
CN	214232565	U	9/2021	
CN	113499572	A	10/2021	
CN	113521655	A	10/2021	
CN	214388673	U	10/2021	
CN	214763119	U	11/2021	
CN	214806540	U	11/2021	
CN	214913108	U	11/2021	
CN	215025723	U	12/2021	
CN	215084603	U	12/2021	
CN	215136488	U	12/2021	
CN	113885361	A	1/2022	
CN	114049961	A	2/2022	
CN	114203274	A	3/2022	
CN	216258145	U	4/2022	
CN	216366476	U	4/2022	
CN	216497237	U	5/2022	
CN	114632302	A	6/2022	
CN	114694824	A	7/2022	
CN	114898832	A	8/2022	
CN	217246501	U	8/2022	
CN	114983760	A	9/2022	

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

CN	114983761	A	9/2022
CN	115006789	A	9/2022
CN	115089917	A	9/2022
CN	217472652	U	9/2022
CN	110270062	B	10/2022
CN	217612764	U	10/2022
CN	115337599	A	11/2022
CN	115382062	A	11/2022
CN	115487042	A	12/2022
CN	218187703	U	1/2023
CN	218187717	U	1/2023
CN	218420859	U	2/2023
CN	115954081	A	4/2023
DE	95019	C	1/1897
DE	7628633	U1	12/1977
DE	8519150	U1	10/1985
DE	3732905	A1	7/1988
DE	19619820	A1	12/1996
DE	29620008	U1	2/1997
DE	19947926	A1	4/2001
DE	102007025664	A1	12/2008
DE	102018202497	A1	8/2018
DE	102018211212	A1	1/2019
DE	102019108425	B3	8/2020
EP	199600	A2	10/1986
EP	0383137	A2	8/1990
EP	634319	A2	1/1995
EP	0919259	A1	6/1999
EP	1034817	A1	9/2000
EP	1159989	A1	12/2001
EP	1391179	A1	2/2004
EP	1968028		9/2008
EP	2564904	A1	3/2013
EP	2575064	A1	4/2013
EP	1909730	B1	4/2014
EP	2815242	A4	12/2014
EP	2869805	A	5/2015
EP	2997951	A1	3/2016
EP	2688472	B1	4/2016
EP	3264303	A1	1/2018
EP	3323473	A1	5/2018
EP	3547322	A1	10/2019
EP	3627514	A1	3/2020
EP	3671700	A1	6/2020
EP	3688537	A1	8/2020
EP	3731733	A1	11/2020
EP	3984508	A1	4/2022
EP	3984509	A1	4/2022
EP	3984510	A1	4/2022
EP	3984511	A1	4/2022
EP	3984512	A1	4/2022
EP	3984513	A1	4/2022
EP	4054699	A1	9/2022
EP	4112033	A1	1/2023
FR	2527541	A2	12/1983
FR	3127393	A1	3/2023
GB	141664	A	11/1920
GB	2336140	A	10/1999
GB	2372459	A	8/2002
GB	2512431	A	10/2014
GB	2591542	B	3/2022
IN	23/2009		5/2009
IN	201811043670	A	7/2018
JP	2000005339	A	1/2000
JP	2003225875	A	8/2003
JP	2005227928	A	8/2005
JP	2005227928	A1	8/2005
JP	2009112336	A	5/2009
JP	2013515995	A	5/2013
JP	2014104139	A	6/2014
JP	3193662	U	10/2014
JP	3198173	U	6/2015
JP	5804063	B2	11/2015
JP	2018102842	A	7/2018
JP	6454071	B2	1/2019
JP	2019028647	A	2/2019
JP	2019134909	A	8/2019
JP	6573739	B1	9/2019
JP	6659831	B2	3/2020
JP	2020057082	A	4/2020
JP	6710357	B1	6/2020
JP	6775757	B1	10/2020
JP	2021027917	A	2/2021
JP	2021040882	A	3/2021
JP	6871379	B2	5/2021
JP	2022521378	A	4/2022
JP	3238491	U	7/2022
JP	7198364	B2	12/2022
JP	7202474	B2	1/2023
JP	7231750	B2	3/2023
JP	7231751	B2	3/2023
JP	7231752	B2	3/2023
KR	20020009724	A	2/2002
KR	200276919	Y1	5/2002
KR	20020065253	A	8/2002
KR	20040082259	A	9/2004
KR	100582596	B1	5/2006
KR	101042258	B1	6/2011
KR	101258250	B1	4/2013
KR	101325581	B1	11/2013
KR	20140128630	A	11/2014
KR	20150017693	A	2/2015
KR	20150078191	A	7/2015
KR	101580071	B1	12/2015
KR	101647620	B1	8/2016
KR	20160093990	A	8/2016
KR	20170038837	A	4/2017
KR	20170086922	A	7/2017
KR	20180004928	A	1/2018
KR	20190016727	A	2/2019
KR	20190029175	A	3/2019
KR	20190056116	A	5/2019
KR	101988167	B1	6/2019
KR	101969392	B1	8/2019
KR	102038055	B1	10/2019
KR	102043239	B1	11/2019
KR	102055279	B1	12/2019
KR	20200019548	A	2/2020
KR	102088333	B1	3/2020
KR	20200025290	A	3/2020
KR	20200029180	A	3/2020
KR	102097190	B1	4/2020
KR	102116664	B1	5/2020
KR	102116968	B1	5/2020
KR	20200056233	A	5/2020
KR	102120828	B1	6/2020
KR	102121586	B1	6/2020
KR	102142713	B1	8/2020
KR	102162522	B1	10/2020
KR	20200119665	A	10/2020
KR	102173553	B1	11/2020
KR	102180079	B1	11/2020
KR	102188766	B1	12/2020
KR	102196793	B1	12/2020
KR	20210006212	A	1/2021
KR	102224188	B1	3/2021
KR	102224618	B1	3/2021
KR	102246049	B1	4/2021
KR	102246050	B1	4/2021
KR	102246051	B1	4/2021
KR	102246052	B1	4/2021
KR	20210052028	A	5/2021
KR	102264498	B1	6/2021
KR	102352602	B1	1/2022
KR	102352603	B1	1/2022
KR	102352604	B1	1/2022
KR	20220004639	A	1/2022
KR	102387577	B1	4/2022
KR	102421437	B1	7/2022
KR	20220102207	A	7/2022
KR	102427545	B1	8/2022
KR	102467495	B1	11/2022
KR	102467496	B1	11/2022
KR	102469723	B1	11/2022

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

KR	102471990	B1	11/2022	
KR	20220145989	A	11/2022	
KR	20220156134	A	11/2022	
KR	102502744	B1	2/2023	
KR	20230019349	A	2/2023	
KR	20230019350	A	2/2023	
KR	20230026556	A	2/2023	
KR	20230026668	A	2/2023	
KR	20230040526		3/2023	
KR	20230050506	A	4/2023	
KR	20230056118	A	4/2023	
KR	102528503	B1	5/2023	
KR	102531930	B1	5/2023	
KR	102532766	B1	5/2023	
KR	102539190	B1	6/2023	
PL	P.401020		4/2014	
RU	2154460	C2	8/2000	
RU	2014131288	A	2/2016	
RU	2607953	C2	1/2017	
RU	2738571	C1	12/2020	
TW	M474545	U	3/2014	
TW	I442956	B	7/2014	
TW	M638437	U	3/2023	
WO	1998009687	A1	3/1998	
WO	9912468		3/1999	
WO	0149235	A2	7/2001	
WO	0151083	A2	7/2001	
WO	2001050387	A1	7/2001	
WO	2001056465	A1	8/2001	
WO	02062211	A2	8/2002	
WO	02093312	A2	11/2002	
WO	2003043494	A1	5/2003	
WO	2005018453	A1	3/2005	
WO	WO-2005074369	A2 *	8/2005	..... A61B 5/103
WO	2006004430	A2	1/2006	
WO	2006012694	A1	2/2006	
WO	2007102709	A1	9/2007	
WO	2008114291	A1	9/2008	
WO	2009003170	A1	12/2008	
WO	2009008968	A1	1/2009	
WO	2011025322	A2	3/2011	
WO	2012128801	A1	9/2012	
WO	2013002568	A2	1/2013	
WO	2023164292	A1	3/2013	
WO	2013122839	A1	8/2013	
WO	2014011447	A1	1/2014	
WO	2014039567	A1	3/2014	
WO	2014163976	A1	10/2014	
WO	2015026744	A1	2/2015	
WO	2015065298	A1	5/2015	
WO	2015082555	A1	6/2015	
WO	2016151364	A1	9/2016	
WO	2016154318	A1	9/2016	
WO	2017030781	A1	2/2017	
WO	2017166074	A1	5/2017	
WO	2017091691	A1	6/2017	
WO	2017165238	A1	9/2017	
WO	2018081795	A1	5/2018	
WO	2018171853	A1	9/2018	
WO	2019022706	A1	1/2019	
WO	2019143940	A1	7/2019	
WO	2020075190	A1	4/2020	
WO	2020130979	A1	6/2020	
WO	2020149815	A2	7/2020	
WO	2020158904	A1	8/2020	
WO	2020229705	A1	11/2020	
WO	2020245727	A1	12/2020	
WO	2020249855	A1	12/2020	
WO	2020252599	A1	12/2020	
WO	2020256577	A1	12/2020	
WO	2021021447	A1	2/2021	
WO	2021022003	A1	2/2021	
WO	2021038980	A1	3/2021	
WO	2021055427	A1	3/2021	
WO	2021061061	A1	4/2021	
WO	2021090267	A1	5/2021	
WO	2021138620	A1	7/2021	
WO	2021216881	A1	10/2021	
WO	2021236961	A1	11/2021	
WO	2022047006	A1	3/2022	
WO	2022092493	A1	5/2022	
WO	2022092494	A1	5/2022	
WO	2022212883	A1	10/2022	
WO	2022212921	A1	10/2022	
WO	2022216498	A1	10/2022	
WO	2022251420	A1	12/2022	
WO	2023008680	A1	2/2023	
WO	2023008681	A1	2/2023	
WO	2023022319	A1	2/2023	
WO	2023022320	A1	2/2023	
WO	2023052695	A1	4/2023	
WO	2023091496	A1	5/2023	
WO	2023215155	A1	11/2023	
WO	2023230075	A1	11/2023	
WO	2024013267	A1	1/2024	
WO	2024107807	A1	5/2024	

OTHER PUBLICATIONS

International Searching Authority, International Preliminary Report on Patentability of International Application No. PCT/US2017/50895, Date of Mailing Dec. 11, 2018, 52 pages.

International Searching Authority, Search Report and Written Opinion for International Application No. PCT/US2017/50895, Date of Mailing Jan. 12, 2018, 6 pages.

International Searching Authority, Search Report and Written Opinion for International Application No. PCT/US2020/021876, Date of Mailing May 28, 2020, 8 pages.

International Searching Authority, Search Report and Written Opinion for International Application No. PCT/US2020/051008, Date of Mailing Dec. 10, 2020, 9 pages.

International Searching Authority, Search Report and Written Opinion for International Application No. PCT/US2020/056661, Date of Mailing Feb. 12, 2021, 12 pages.

International Searching Authority, Search Report and Written Opinion for International Application No. PCT/US2021/032807, Date of Mailing Sep. 6, 2021, 11 pages.

Matrix, R3xm Recumbent Cycle, retrieved on Aug. 4, 2020, 7 pages, https://www.matrixfitness.com/en/cardio/cycles/r3xm-recumbent.

ROM3 Rehab, ROM3 Rehab System, Apr. 20, 2015, retrieved on Aug. 31, 2018, 12 pages, https://vimeo.com/125438463.

Ahmed et al., "Artificial Intelligence With Multi-Functional Machine Learning Platform Development for Better Healthcare and Precision Medicine," Database (Oxford), 2020, pp. 1-35, vol. 2020.

Davenport et al., "The Potential For Artificial Intelligence in Healthcare," Future Healthcare Journal, 2019, pp. 94-98, vol. 6, No. 2.

Alcaraz et al., "Machine Learning as Digital Therapy Assessment for Mobile Gait Rehabilitation," 2018 IEEE 28th International Workshop on Machine Learning for Signal Processing (MLSP), Aalborg, Denmark, 2018, 6 pages.

Androutsou et al., "A Smartphone Application Designed to Engage the Elderly in Home-Based Rehabilitation," Frontiers in Digital Health, Sep. 2020, vol. 2, Article 15, 13 pages.

Silva et al., "SapoFitness: A mobile health application for dietary evaluation," 2011 IEEE 13th International Conference on U e-Health Networking, Applications and Services, Columbia, MO, USA, 2011, 6 pages.

Wang et al., "Interactive wearable systems for upper body rehabilitation: a systematic review," Journal of NeuroEngineering and Rehabilitation, 2017, 21 pages.

Marzolini et al., "Eligibility, Enrollment, and Completion of Exercise-Based Cardiac Rehabilitation Following Stroke Rehabilitation: What Are the Barriers?," Physical Therapy, vol. 100, No. 1, 2019, 13 pages.

Nijjar et al., "Randomized Trial of Mindfulness-Based Stress Reduction in Cardiac Patients Eligible for Cardiac Rehabilitation," Scientific Reports, 2019, 12 pages.

(56) **References Cited**

OTHER PUBLICATIONS

Lara et al., "Human-Robot Sensor Interface for Cardiac Rehabilitation," IEEE International Conference on Rehabilitation Robotics, Jul. 2017, 8 pages.

Ishraque et al., "Artificial Intelligence-Based Rehabilitation Therapy Exercise Recommendation System," 2018 IEEE Mit Undergraduate Research Technology Conference (URTC), Cambridge, MA, USA, 2018, 5 pages.

Zakari et al., "Are There Limitations to Exercise Benefits in Peripheral Arterial Disease?," Frontiers in Cardiovascular Medicine, Nov. 2018, vol. 5, Article 173, 12 pages.

You et al., "Including Blood Vasculature into a Game-Theoretic Model of Cancer Dynamics," Games 2019, 10, 13, 22 pages.

Jeong et al., "Computer-assisted upper extremity training using interactive biking exercise (iBikE) platform," Sep. 2012, 34th Annual International Conference of the IEEE EMBS, 5 pages.

Gerbild et al., "Physical Activity to Improve Erectile Dysfunction: A Systematic Review of Intervention Studies," Sexual Medicine, 2018, 15 pages.

Jeong et al., "Computer-assisted upper extremity training using interactive biking exercise (iBikE) platform," Sep. 2012, pp. 1-5, 34th Annual International Conference of the IEEE EMBS.

Website for "Pedal Exerciser", p. 1, retrieved on Sep. 9, 2022 from https://www.vivehealth.com/collections/physical-therapy-equipment/products/pedalexerciser.

Website for "Functional Knee Brace with ROM", p. 1, retrieved on Sep. 9, 2022 from http://medicalbrace.gr/en/product/functional-knee-brace-with-goniometer-mbtelescopicknee/.

Website for "ComfySplints Goniometer Knee", pp. 1-5, retrieved on Sep. 9, 2022 from https://www.comfysplints.com/product/knee-splints/.

Website for "BMI FlexEze Knee Corrective Orthosis (KCO)", pp. 1-4, retrieved on Sep. 9, 2022 from https://orthobmi.com/products/bmi-flexeze%C2%AE-knee-corrective-orthosis-kco.

Website for "Neoprene Knee Brace with goniometer—Patella ROM MB.4070", pp. 1-4, retrieved on Sep. 9, 2022 from https://www.fortuna.com.gr/en/product/neoprene-knee-brace-with-goniometer-patella-rom-mb-4070/.

Kuiken et al., "Computerized Biofeedback Knee Goniometer: Acceptance and Effect on Exercise Behavior in Post-total Knee Arthroplasty Rehabilitation," Biomedical Engineering Faculty Research and Publications, 2004, pp. 1-10.

Ahmed et al., "Artificial intelligence with multi-functional machine learning platform development for better healthcare and precision medicine," Database, 2020, pp. 1-35.

Davenport et al., "The potential for artificial intelligence in healthcare," Digital Technology, Future Healthcare Journal, 2019, pp. 1-5, vol. 6, No. 2.

Website for "OxeFit XS1", pp. 1-3, retrieved on Sep. 9, 2022 from https://www.oxefit.com/xs1.

Website for "Preva Mobile", pp. 1-6, retrieved on Sep. 9, 2022 from https://www.precor.com/en-us/resources/introducing-preva-mobile.

Website for "J-Bike", pp. 1-3, retrieved on Sep. 9, 2022 from https://www.magneticdays.com/en/cycling-for-physical-rehabilitation.

Website for "Excy", pp. 1-12, retrieved on Sep. 9, 2022 from https://excy.com/portable-exercise-rehabilitation-excy-xcs-pro/.

Website for "OxeFit XP1", p. 1, retrieved on Sep. 9, 2022 from https://www.oxefit.com/xp1.

Malloy, Online Article "Al-enabled EKGs find difference between numerical age and biological age significantly affects health, longevity", Website: https://newsnetwork.mayoclinic.org/discussion/ai-enabled-ekgs-find-difference-between-numerical-age-and-biological-age-significantly-affects-health-longevity/, Mayo Clinic News Network, May 20, 2021, retrieved: Jan. 23, 2023, p. 1-4.

Chrif et al., "Control design for a lower-limb paediatric therapy device using linear motor technology," Article, 2017, pp. 119-127, Science Direct, Switzerland.

Robben et al., "Delta Features From Ambient Sensor Data are Good Predictors of Change in Functional Health," Article, 2016, pp. 2168-2194, vol. 21, No. 4, IEEE Journal of Biomedical and Health Informatics.

Kantoch et al., "Recognition of Sedentary Behavior by Machine Learning Analysis of Wearable Sensors during Activities of Daily Living for Telemedical Assessment of Cardiovascular Risk," Article, 2018, 17 pages, Sensors, Poland.

Warburton et al., "International Launch of the Par-•Q+ and ePARmed-•X+ Validation of the PAR-•Q+ and ePARmed••X+," Health & Fitness Journal of Canada, 2011, 9 pages, vol. 4, No. 2.

Barrett et al., "Artificial intelligence supported patient self-care in chronic heart failure: a paradigm shift from reactive to predictive, preventive and personalised care," EPMA Journal (2019), pp. 445-464.

Oerkild et al., "Home-based cardiac rehabilitation is an attractive alternative to No. cardiac rehabilitation for elderly patients with coronary heart disease: results from a randomised clinical trial," BMJ Open Accessible Medical Research, Nov. 22, 2012, pp. 1-9.

Bravo-Escobar et al., "Effectiveness and safety of a home-based cardiac rehabilitation programme of mixed surveillance in patients with ischemic heart disease at moderate cardiovascular risk: A randomised, controlled clinical trial," BMC Cardiovascular Disorders, 2017, pp. 1-11, vol. 17:66.

Thomas et al., "Home-Based Cardiac Rehabilitation," Circulation, 2019, pp. e69-e89, vol. 140.

Thomas et al., "Home-Based Cardiac Rehabilitation," Journal of the American College of Cardiology, Nov. 1, 2019, pp. 133-153, vol. 74.

Thomas et al., "Home-Based Cardiac Rehabilitation," HHS Public Access, Oct. 2, 2020, pp. 1-39.

Dittus et al., "Exercise-Based Oncology Rehabilitation: Leveraging the Cardiac Rehabilitation Model," Journal of Cardiopulmonary Rehabilitation and Prevention, 2015, pp. 130-139, vol. 35.

Chen et al., "Home-based cardiac rehabilitation improves quality of life, aerobic capacity, and readmission rates in patients with chronic heart failure," Medicine, 2018, pp. 1-5 vol. 97:4.

Lima de Melo Ghisi et al., "A systematic review of patient education in cardiac patients: Do they increase knowledge and promote health behavior change?," Patient Education and Counseling, 2014, pp. 1-15.

Fang et al., "Use of Outpatient Cardiac Rehabilitation Among Heart Attack Survivors—20 States and the District of Columbia, 2013 and Four States, 2015," Morbidity and Mortality Weekly Report, vol. 66, No. 33, Aug. 25, 2017, pp. 869-873.

Beene et al., "AI and Care Delivery: Emerging Opportunities for Artificial Intelligence to Transform How Care Is Delivered," Nov. 2019, American Hospital Association, pp. 1-12.

Jennifer Bresnick, "What is the Role of Natural Language Processing in Healthcare?", pp. 1-7, published Aug. 18, 2016, retrieved on Feb. 1, 2022 from https://healthitanalytics.com/ featu res/what-is-the-role-of-natural-language-processing-in-healthcare.

Alex Bellec, "Part-of-Speech tagging tutorial with the Keras Deep Learning library," pp. 1-16, published Mar. 27, 2018, retrieved on Feb. 1, 2022 from https://becominghuman.ai/part-of-speech-tagging-tutorial-with-the-keras-deep-learning-library-d7f93fa05537.

Kavita Ganesan, All you need to know about text preprocessing for NLP and Machine Learning, pp. 1-14, published Feb. 23, 2019, retrieved on Feb. 1, 2022 from https:// towardsdatascience.com/all-you-need-to-know-about-text-preprocessing-for-nlp-and-machine-learning-bcl c5765ff67.

Badreesh Shetty, "Natural Language Processing (NPL) for Machine Learning," pp. 1-13, published Nov. 24, 2018, retrieved on Feb. 1, 2022 from https://towardsdatascience. com/natural-language-processing-nlp-for-machine-learning-d44498845d5b.

Boulanger Pierre et al., "A Low-cost Virtual Reality Bike for Remote Cardiac Rehabilitation", Dec. 7, 2017, Advances in Biometrics: International Conference, ICB 2007, Seoul, Korea, pp. 155-166.

Yin Chieh et al., "A Virtual Reality-Cycling Training System for Lower Limb Balance Improvement", BioMed Research International, vol. 2016, pp. 1-10.

(56) **References Cited**

OTHER PUBLICATIONS

Ruiz Ivan et al., "Towards a physical rehabilitation system using a telemedicine approach", Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization, vol. 8, No. 6, Jul. 28, 2020, pp. 671-680, XP055914810.

De Canniere Helene et al., "Wearable Monitoring and Interpretable Machine Learning Can Objectively Track Progression in Patients during Cardiac Rehabilitation", Sensors, vol. 20, No. 12, Jun. 26, 2020, XP055914617, pp. 1-15.

International Search Report and Written Opinion for PCT/US2023/014137, dated Jun. 9, 2023, 13 pages.

Website for "Esino 2022 Physical Therapy Equipments Arm Fitness Indoor Trainer Leg Spin Cycle Machine Exercise Bike for Elderly," https://www.made-in-china.com/showroom/esinogroup/product-detailYdZtwGhCMKVR/China-Esino-2022-Physical-Therapy-Equipments-Arm-Fitness-Indoor-Trainer-Leg-Spin-Cycle-Machine-Exercise-Bike-for-Elderly.html, retrieved on Aug. 29, 2023, 5 pages.

Abedtash, "An Interoperable Electronic Medical Record-Based Platform for Personalized Predictive Analytics", ProQuest LLC, Jul. 2017, 185 pages.

Jeong et al., "Remotely controlled biking is associated with improved adherence to prescribed cycling speed," Technology and Health Care 23, 2015, 7 pages.

Laustsen et al., "Telemonitored exercise-based cardiac rehabilitation improves physical capacity and health-related quality of life," Journal of Telemedicine and Telecare, 2020, DOI: 10.1177/1357633X18792808, 9 pages.

Blasiak et al., "CURATE.AI: Optimizing Personalized Medicine with Artificial Intelligence," SLAS Technology: Translating Life Sciences Innovation, 2020, 11 pages.

Abidi, Samina; A Knowledge-Modeling Approach to Integrate Multiple Clinical Practice Guidelines to Provide Evidence-Based Clinical Decision Support for Managing Comorbid Conditions; Journal of Medical Systems 41.12: 1-19. Springer Nature B.V. (Dec. 2017) (Year: 2017).

Fuller, Carole G.; Diagnosis and treatment considerations with comorbid developmentally disabled populations; Journal of Clinical Psychology 54.1: 1-10. John Wiley and Sons Inc. (Han. 1998) (Year: 1998).

He, Jianxing et al. The practical implemenatation of artificial intelligence technologies in medicine. Nature Medicine; New York vol. 25, Iss. 1. Jan. 2019. (Year: 2019).

cG. Acampora, D. J. Cook, P. Rashidi and A. V. Vasilakos, "A Survey on Ambient Intelligence in Healthcare," in Proceedings of the IEEE, vol. 101, vol. 101, No. 12, pp. 2470-2494, Dec. 2013, doi: 10.1109/JPROC.2013.2262913. (Year: 2013).

H. Demirkan, "A Smart Healthcare Systems Framework," in IT Professional, vol. 15, No. 5, pp. 38-45, Sep.-Oct. 2013, doi: 10.1109/MITP.2013.35. (Year: 2013).

W. Rashawn, J. Fowler and A. Arisha, "A Multi-Method Scheduling Framework for Medical Staff," 2018 Winter Simulation Conference (WSC), Gothenburg, Sweden, 2018, pp. 1464-1475, doi: 10.1109/WSC.2018.8632247. (Year: 2018).

* cited by examiner

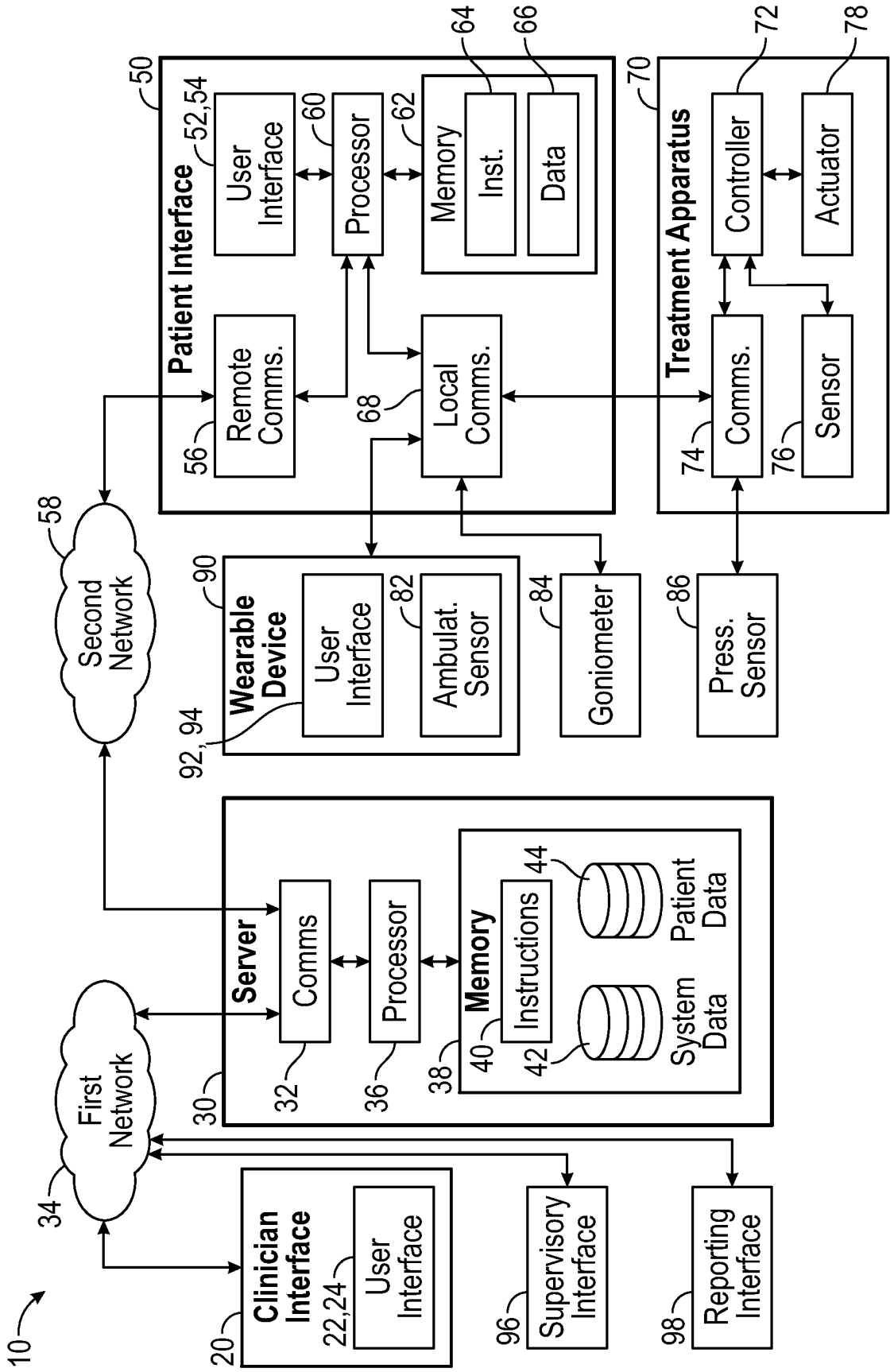
10
First Network
34
Second Network
58
Clinician Interface
20
22,24
User Interface
Server
30
Comms
32
Processor
36
Memory
38
Instructions
40
System Data
42
Patient Data
44
Supervisory Interface
96
Reporting Interface
98
Wearable Device
92,94
90
User Interface
82
Ambulat. Sensor
Goniometer
84
Press. Sensor
86
Patient Interface
50
52,54
User Interface
60
Processor
62
Memory
64
Inst.
66
Data
Remote Comms.
56
Local Comms.
68
Treatment Apparatus
70
Controller
72
Actuator
78
Comms.
74
Sensor
76

FIG. 1

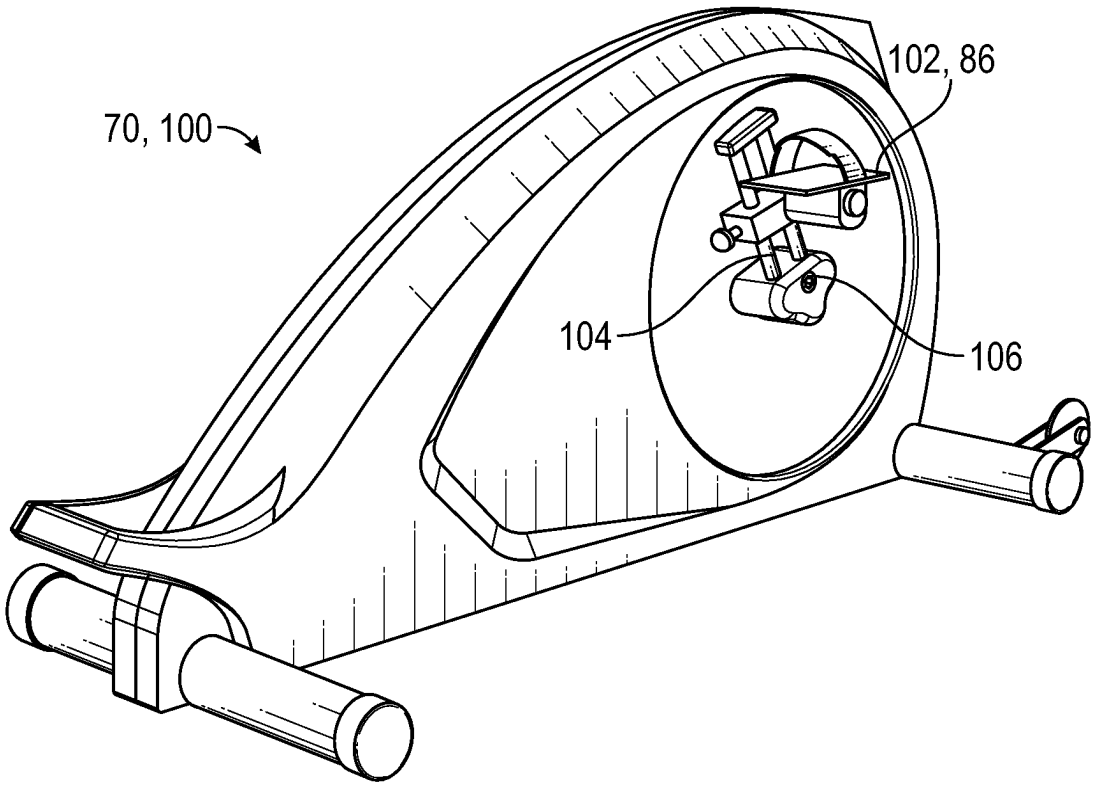

FIG. 2

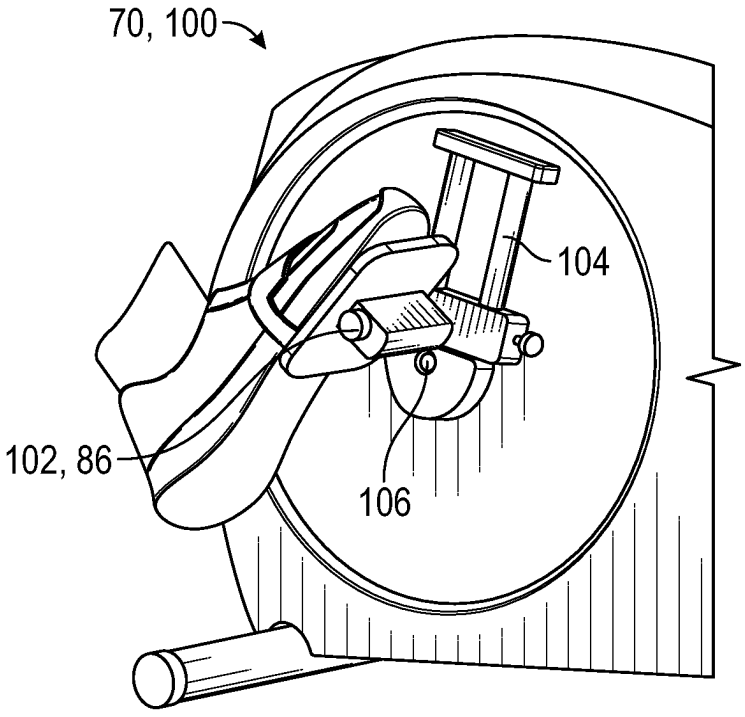

FIG. 3

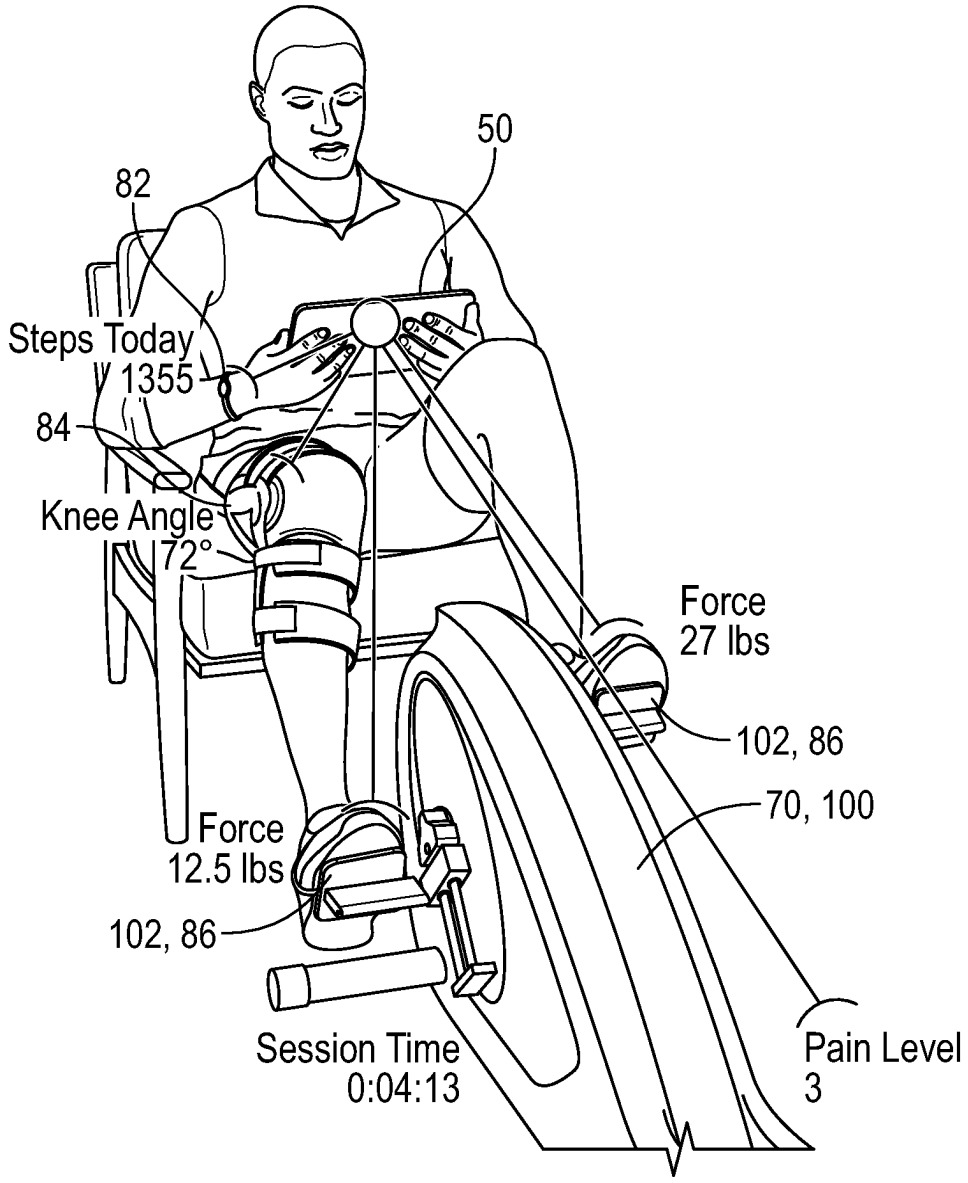
50
82
Steps Today
1355
84
Knee Angle
72°
Force
27 lbs
102, 86
70, 100
Force
12.5 lbs
102, 86
Session Time
0:04:13
Pain Level
3

FIG. 4

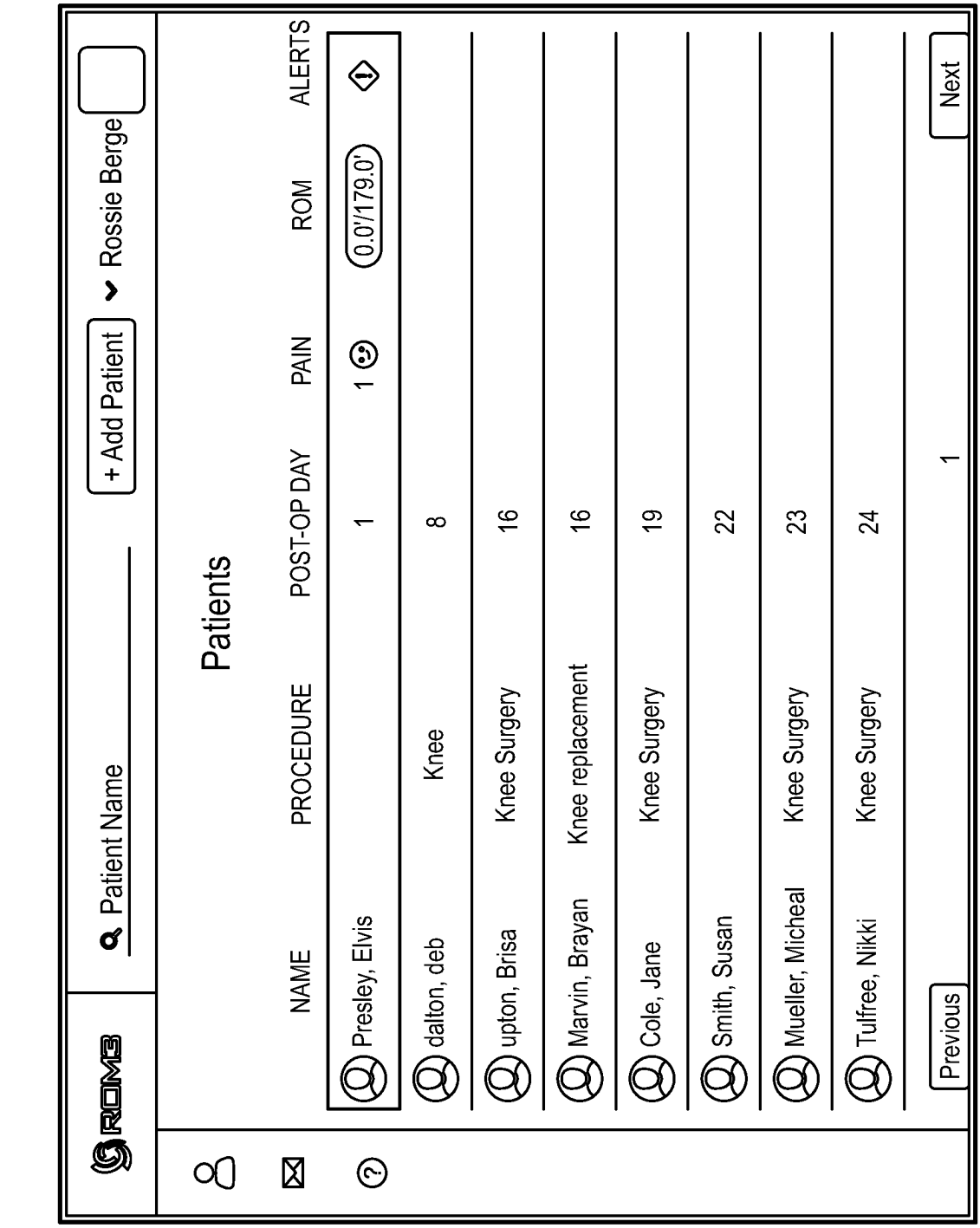
20, 120
ROM3
Patient Name
+ Add Patient
Rossie Berge
Patients
NAME
PROCEDURE
POST-OP DAY
PAIN
ROM
ALERTS
Presley, Elvis
1
1
0.0'/179.0'
dalton, deb
Knee
8
upton, Brisa
Knee Surgery
16
Marvin, Brayan
Knee replacement
16
Cole, Jane
Knee Surgery
19
Smith, Susan
22
Mueller, Micheal
Knee Surgery
23
Tulfree, Nikki
Knee Surgery
24
Previous
1
Next

FIG. 5

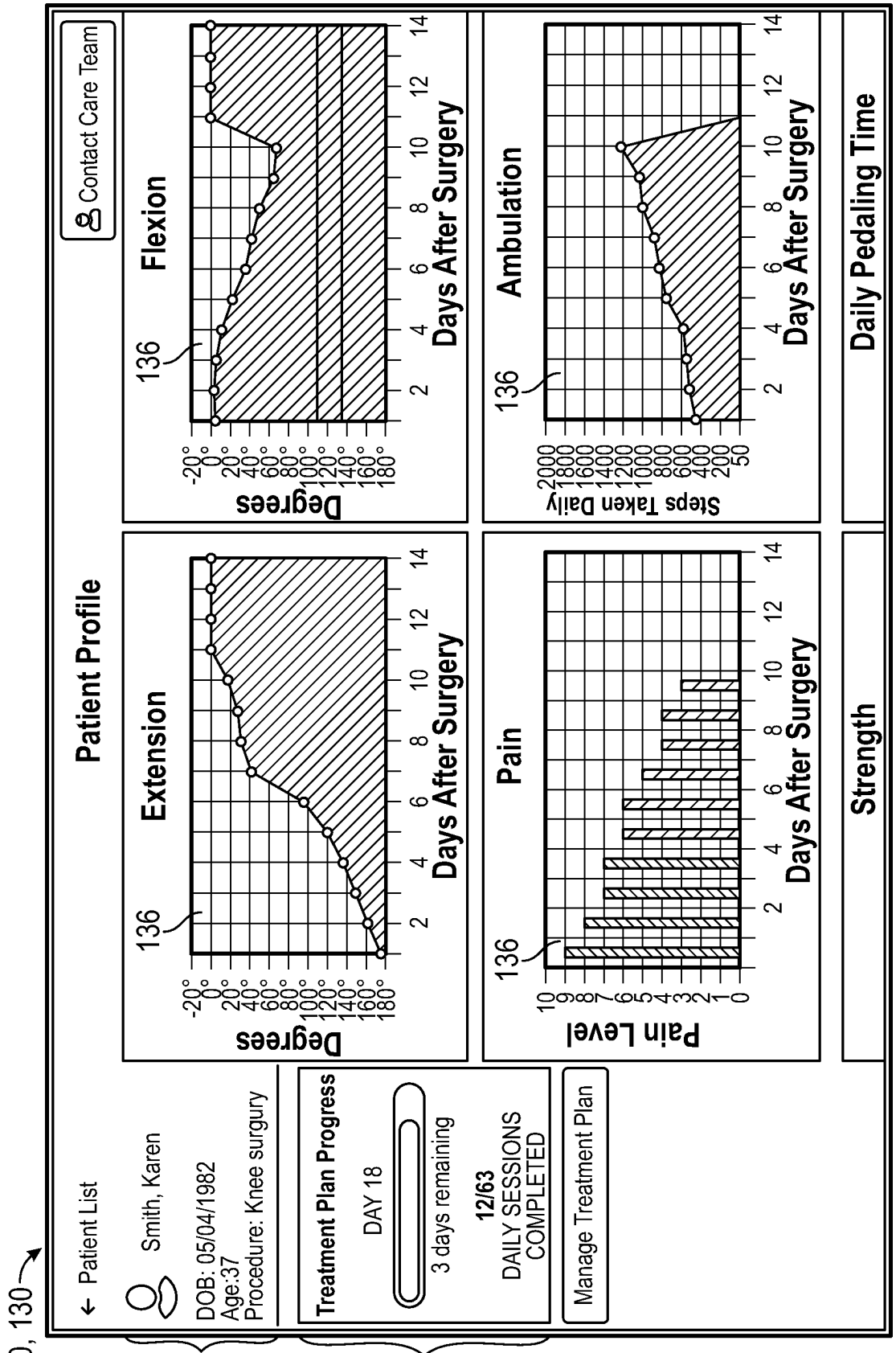
20, 130
132
134
← Patient List
Smith, Karen
DOB: 05/04/1982
Age:37
Procedure: Knee surgury
Patient Profile
Contact Care Team
Treatment Plan Progress
DAY 18
3 days remaining
12/63
DAILY SESSIONS COMPLETED
Manage Treatment Plan
Extension
Flexion
Pain
Ambulation
Strength
Daily Pedaling Time
Degrees
Pain Level
Steps Taken Daily
Days After Surgery
136

FIG. 6

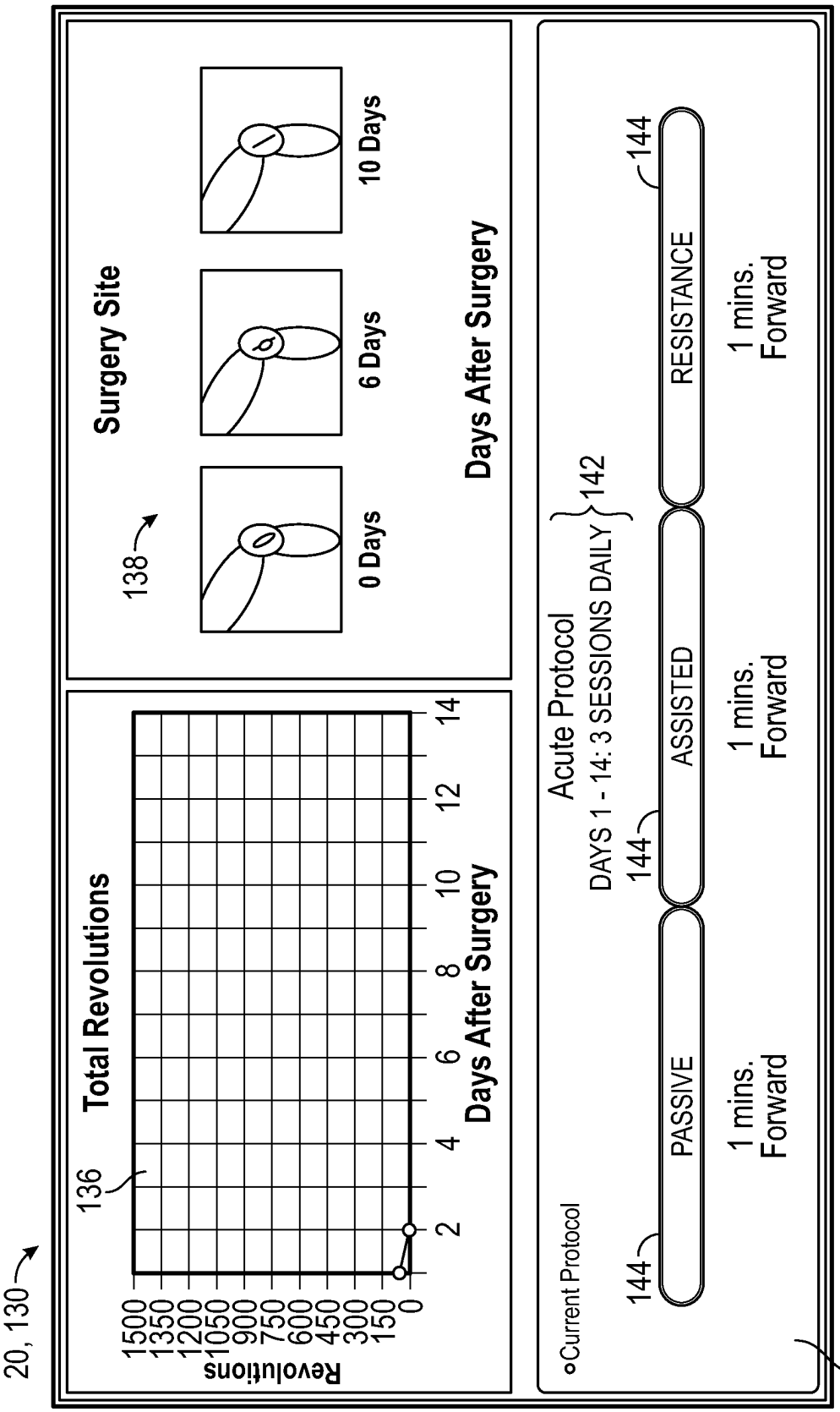
20, 130
Surgery Site
138
0 Days
6 Days
10 Days
Days After Surgery
Total Revolutions
136
Revolutions
1500
1350
1200
1050
900
750
600
450
300
150
0
2
4
6
8
10
12
14
Days After Surgery
Acute Protocol
DAYS 1 - 14: 3 SESSIONS DAILY
142
Current Protocol
144
PASSIVE
1 mins.
Forward
144
ASSISTED
1 mins.
Forward
144
RESISTANCE
1 mins.
Forward
140

FIG. 7

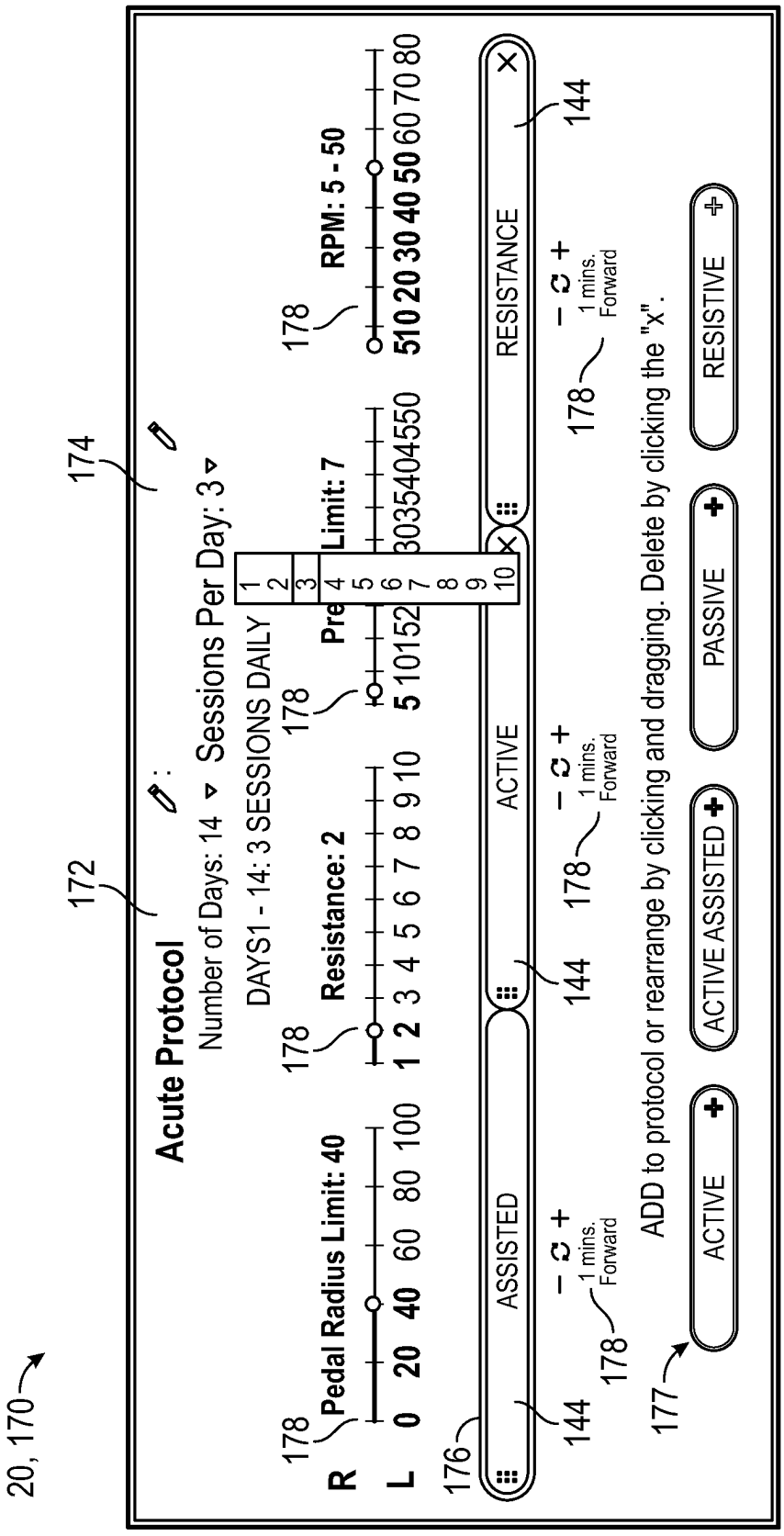
20, 170
172
174
Acute Protocol
Number of Days: 14
Sessions Per Day: 3
DAYS1 - 14: 3 SESSIONS DAILY
178
Pedal Radius Limit: 40
R
L
0 20 40 60 80 100
178
Resistance: 2
1 2 3 4 5 6 7 8 9 10
178
Pre
Limit: 7
5 10 15 20 30 35 40 45 50
178
RPM: 5 - 50
510 20 30 40 50 60 70 80
1 2 3 4 5 6 7 8 9 10
176
ASSISTED
ACTIVE
RESISTANCE
144
144
144
178
1 mins. Forward
178
1 mins. Forward
178
1 mins. Forward
ADD to protocol or rearrange by clicking and dragging. Delete by clicking the "x".
177
ACTIVE
ACTIVE ASSISTED
PASSIVE
RESISTIVE

FIG. 8

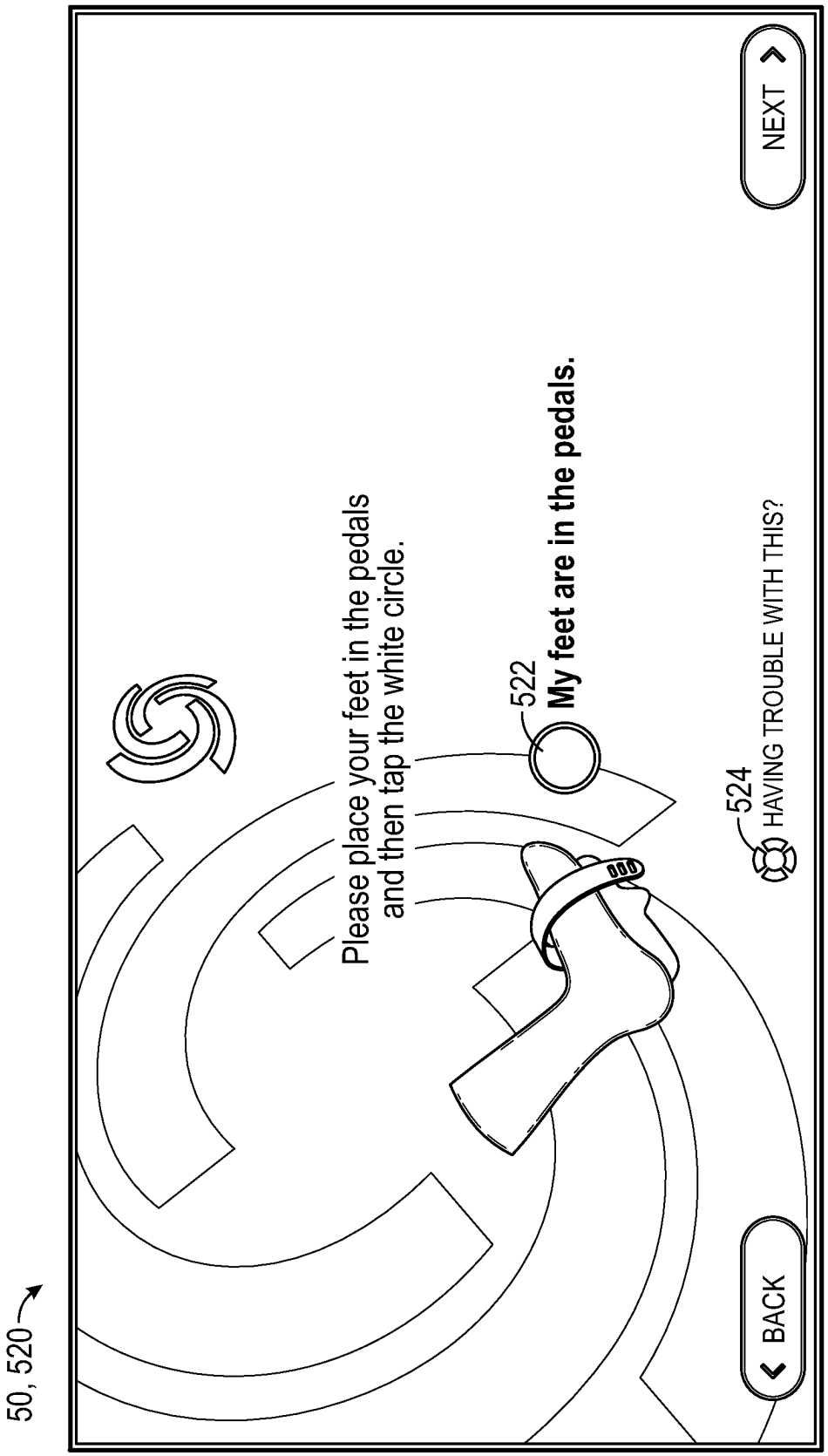
50, 520
BACK
NEXT
Please place your feet in the pedals and then tap the white circle.
522
My feet are in the pedals.
524
HAVING TROUBLE WITH THIS?

FIG. 9

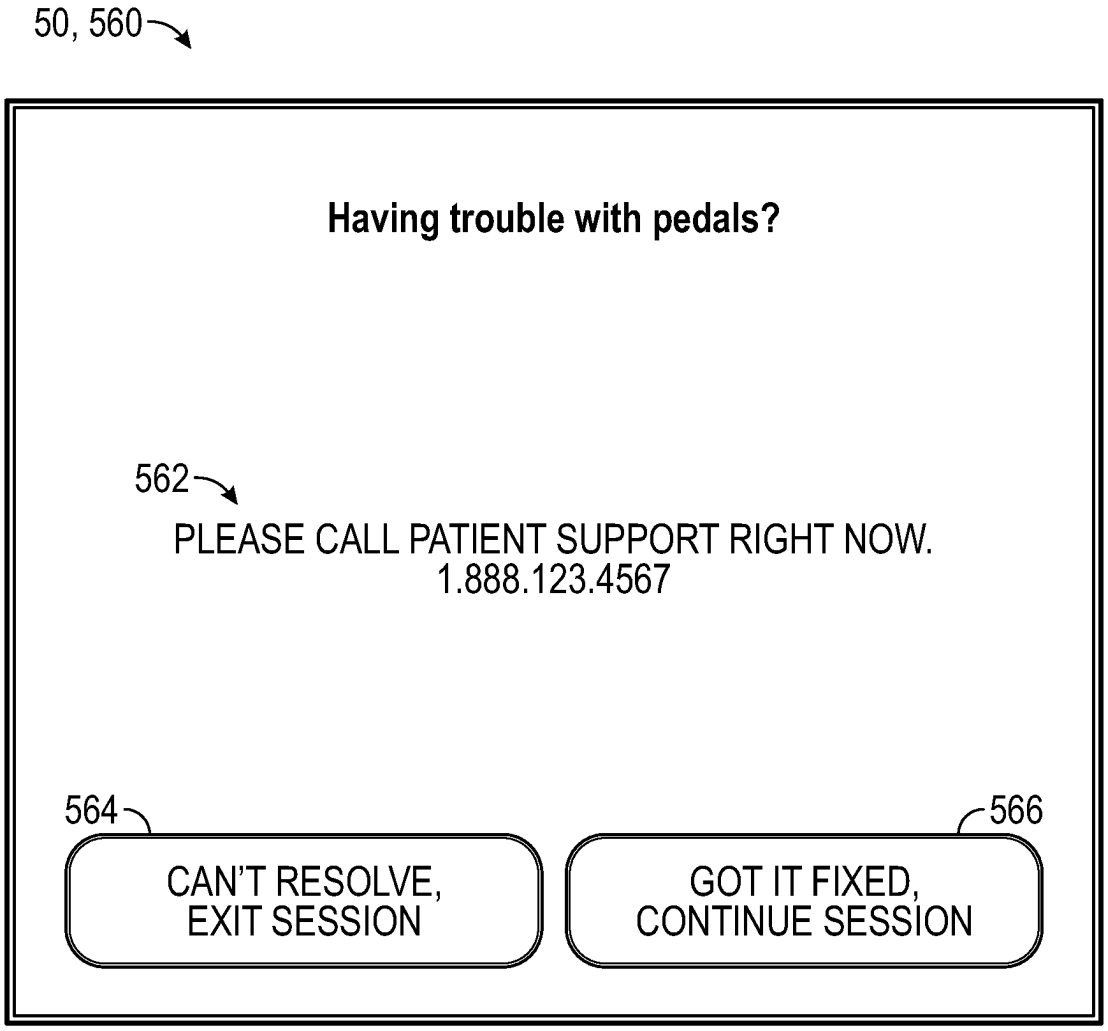
50, 560
Having trouble with pedals?
562
PLEASE CALL PATIENT SUPPORT RIGHT NOW.
1.888.123.4567
564
CAN'T RESOLVE,
EXIT SESSION
566
GOT IT FIXED,
CONTINUE SESSION

FIG. 10

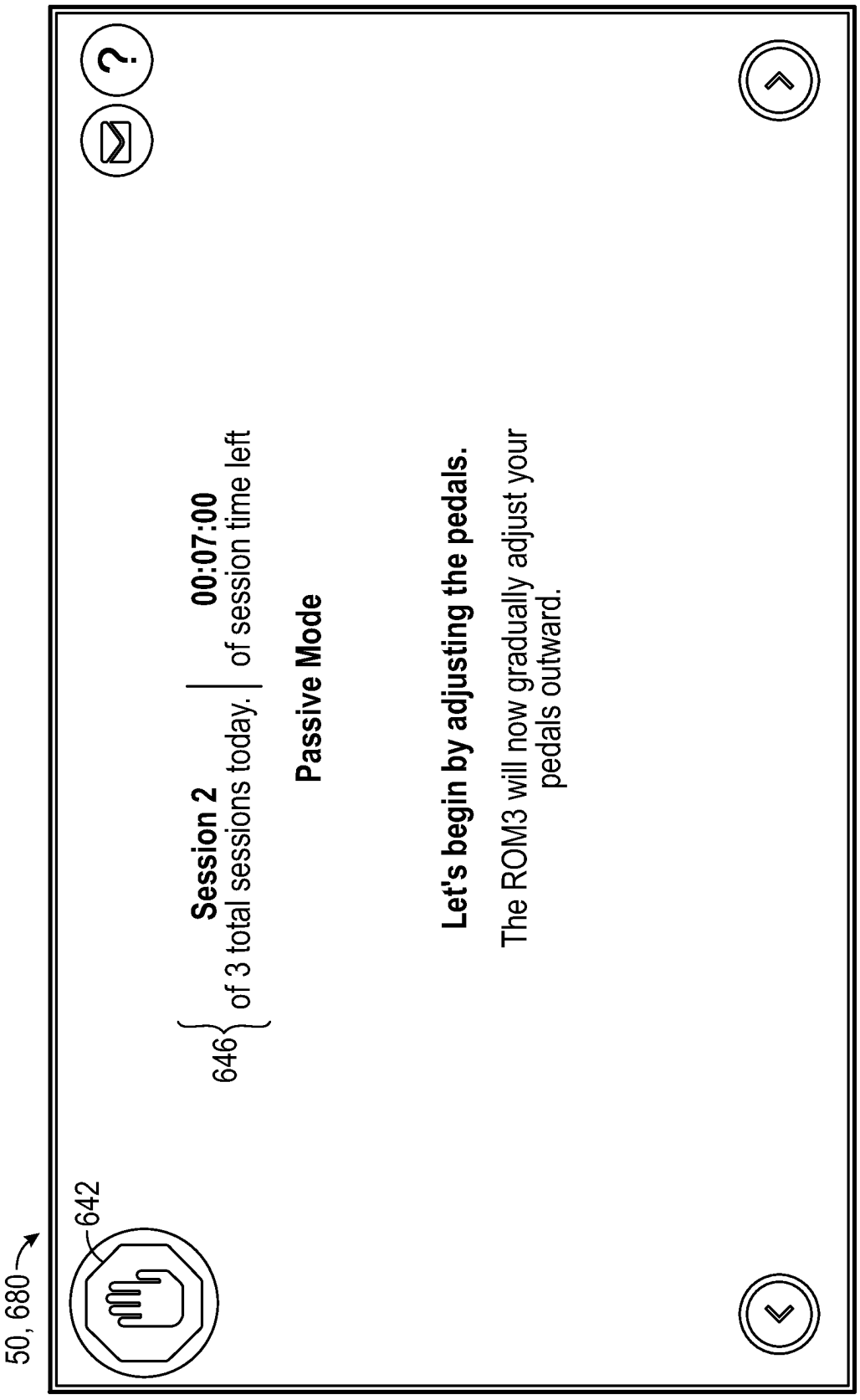
50, 680
642
646
Session 2
of 3 total sessions today.
00:07:00
of session time left
Passive Mode
Let's begin by adjusting the pedals.
The ROM3 will now gradually adjust your pedals outward.

FIG. 11

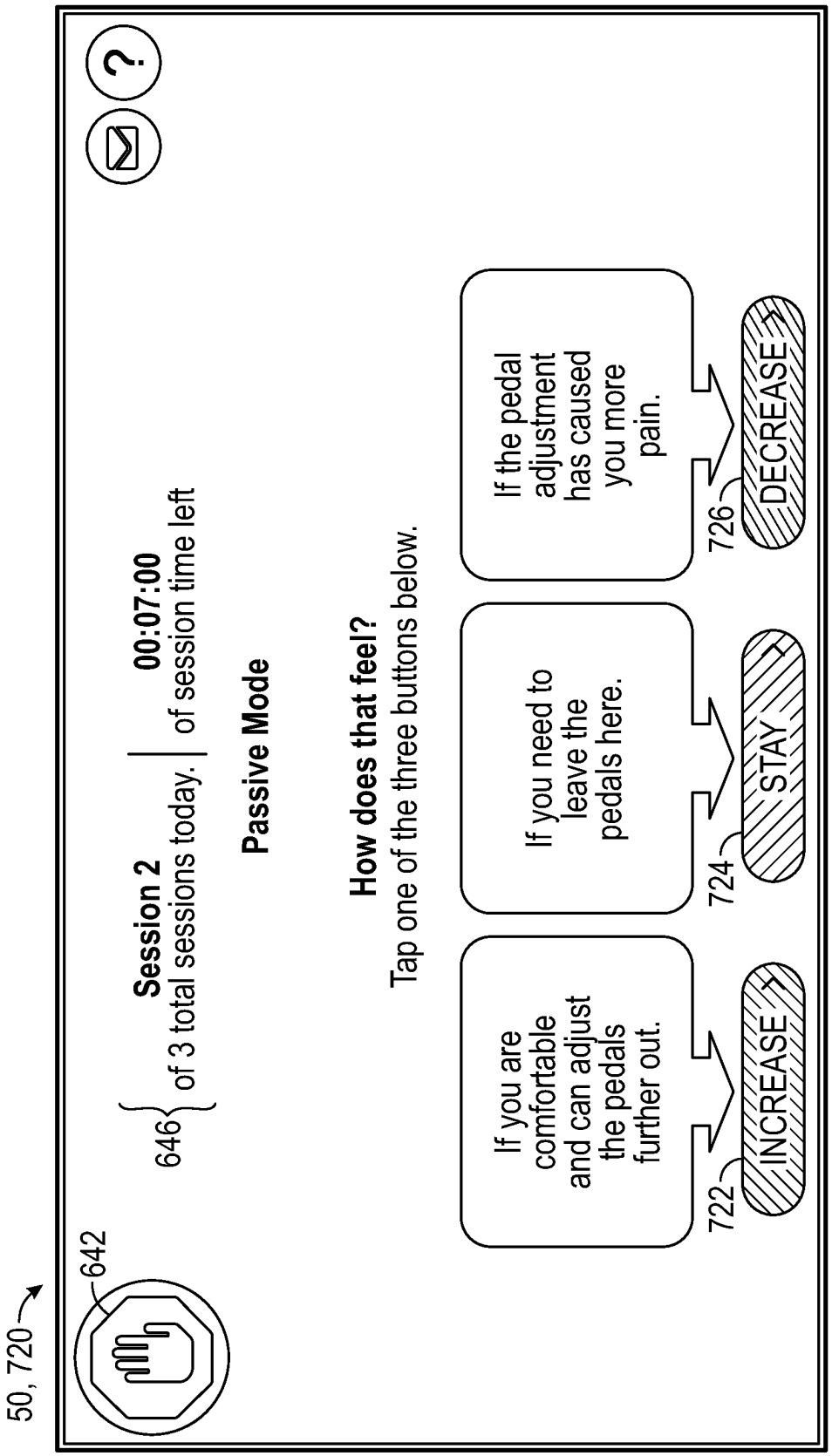
50, 720
642
646
Session 2
of 3 total sessions today.
00:07:00
of session time left
Passive Mode
How does that feel?
Tap one of the three buttons below.
If you are comfortable and can adjust the pedals further out.
722
INCREASE
If you need to leave the pedals here.
724
STAY
If the pedal adjustment has caused you more pain.
726
DECREASE

FIG. 12

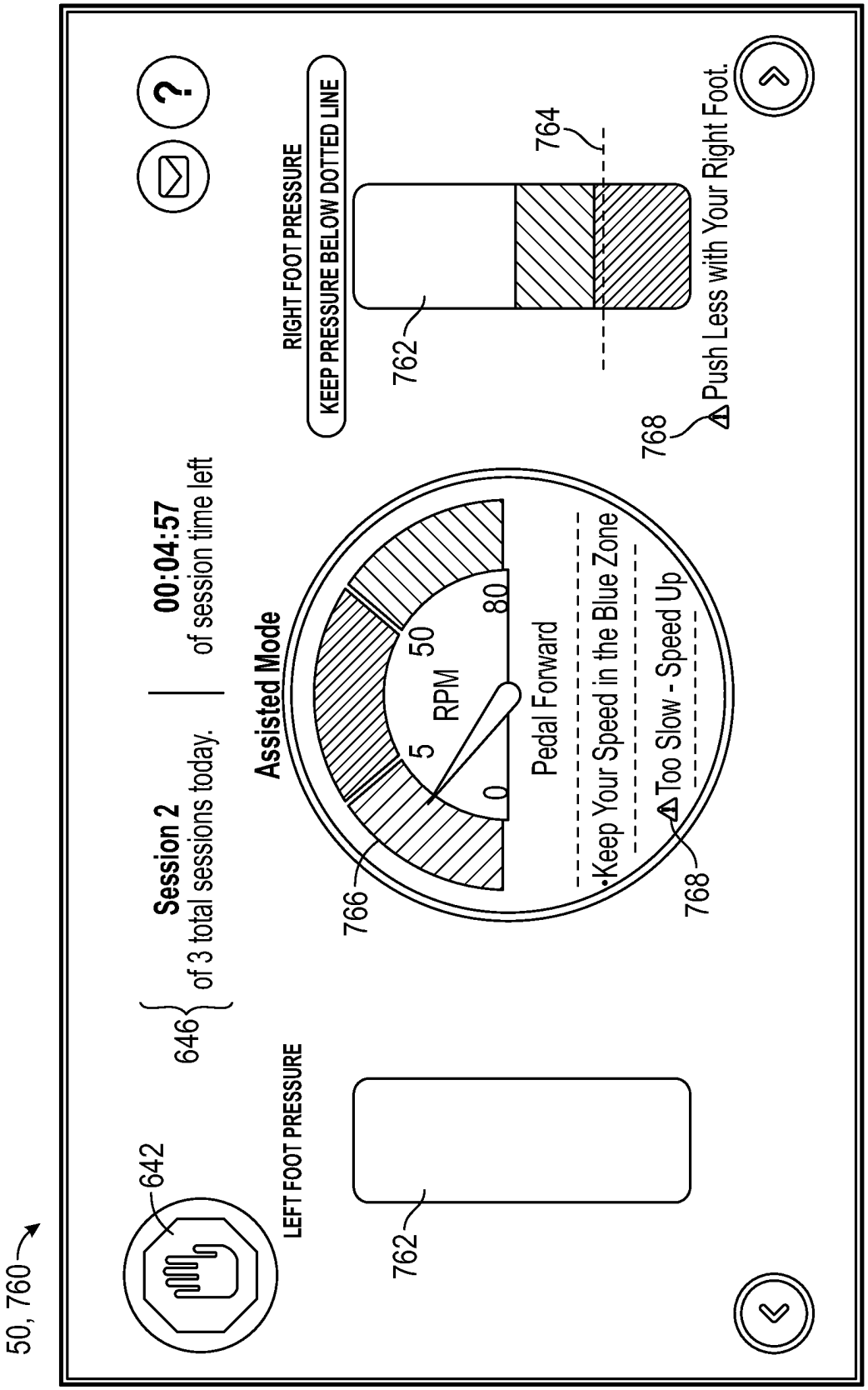
50, 760
642
646
Session 2
of 3 total sessions today.
00:04:57
of session time left
Assisted Mode
LEFT FOOT PRESSURE
762
766
0
5
RPM
50
80
Pedal Forward
Keep Your Speed in the Blue Zone
Too Slow - Speed Up
768
RIGHT FOOT PRESSURE
KEEP PRESSURE BELOW DOTTED LINE
762
764
768
Push Less with Your Right Foot.

FIG. 13

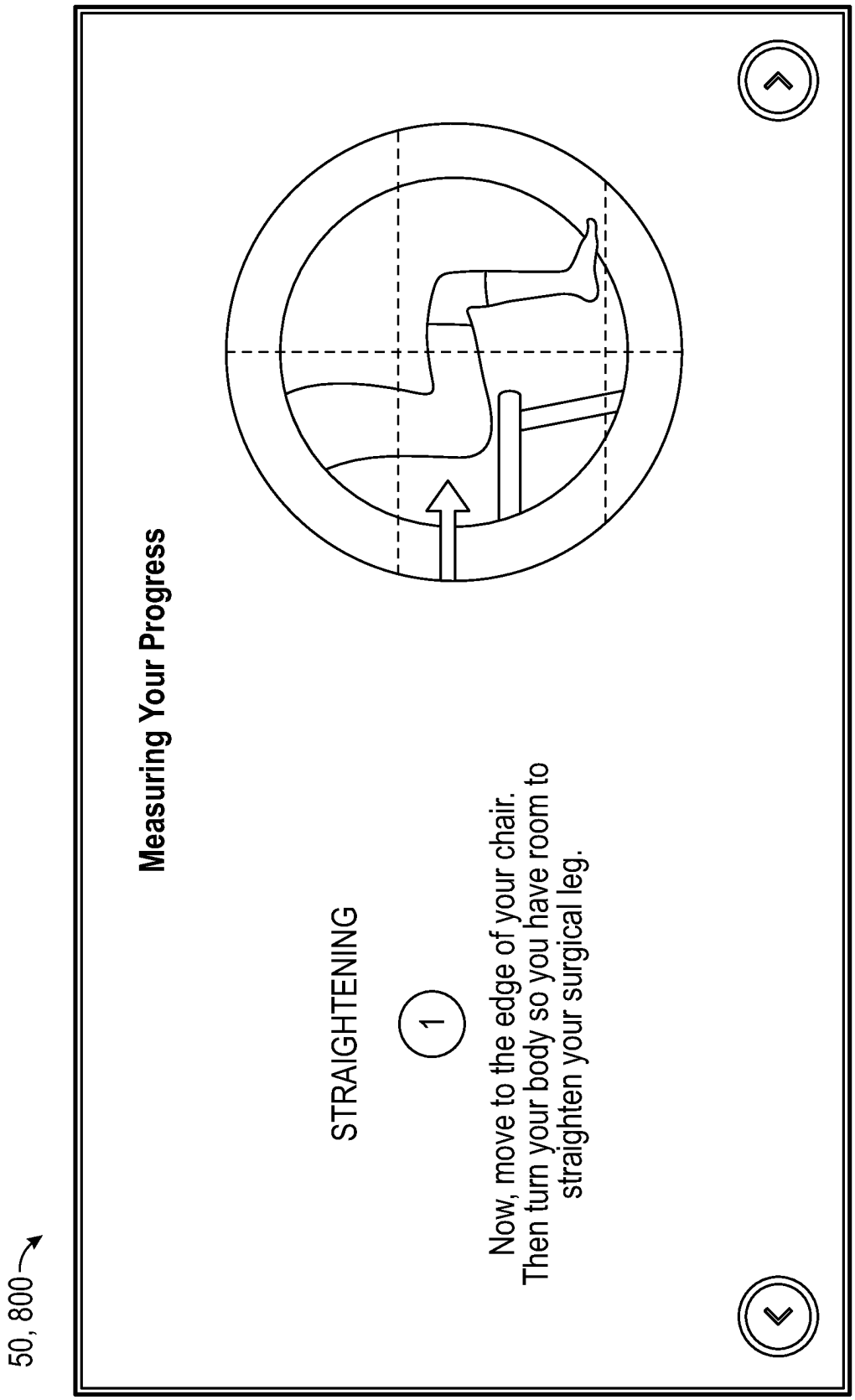
50, 800
Measuring Your Progress
STRAIGHTENING
1
Now, move to the edge of your chair.
Then turn your body so you have room to
straighten your surgical leg.

FIG. 14

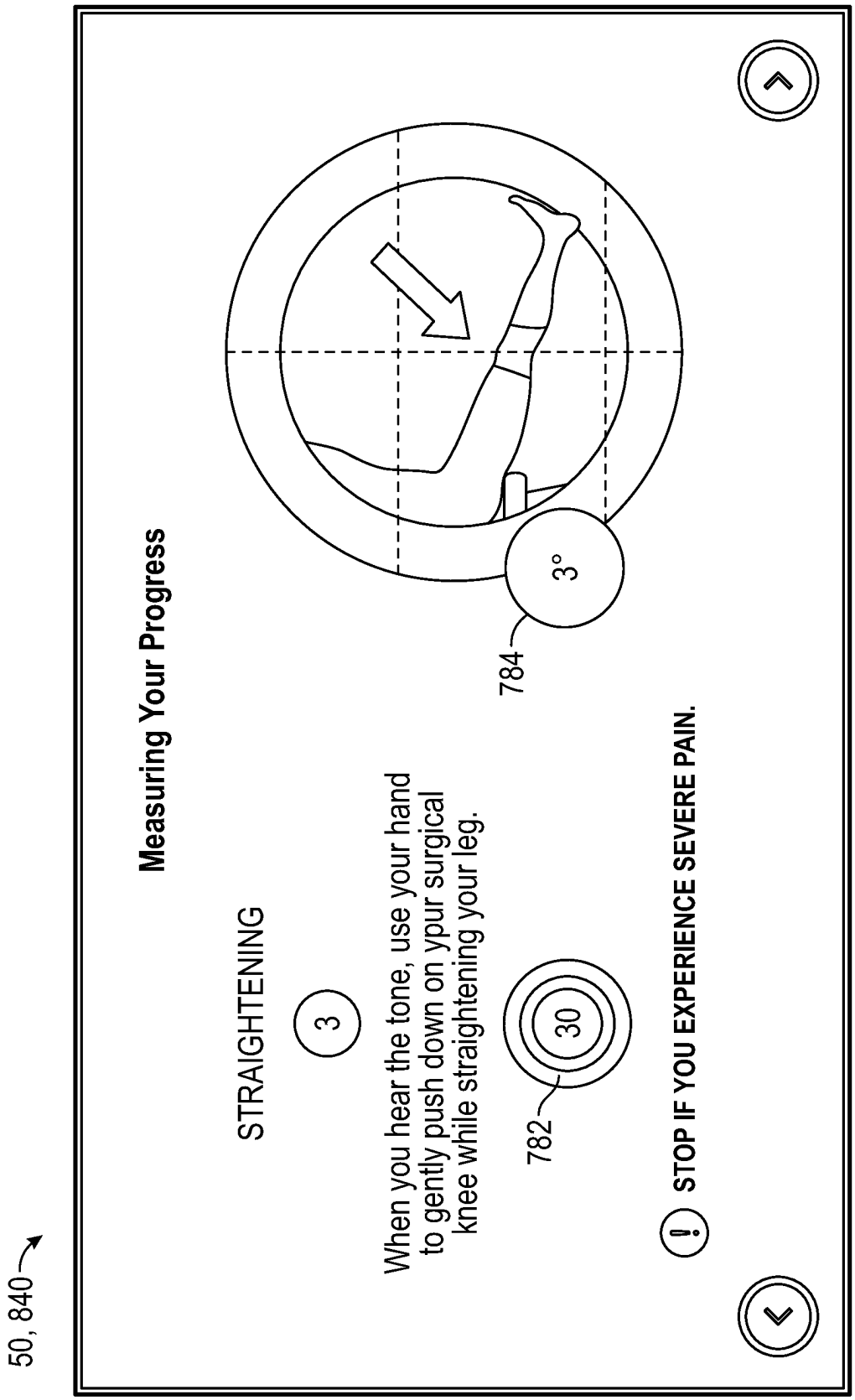
50, 840
Measuring Your Progress
STRAIGHTENING
3
When you hear the tone, use your hand to gently push down on ypur surgical knee while straightening your leg.
782
30
STOP IF YOU EXPERIENCE SEVERE PAIN.
784
3°

FIG. 15

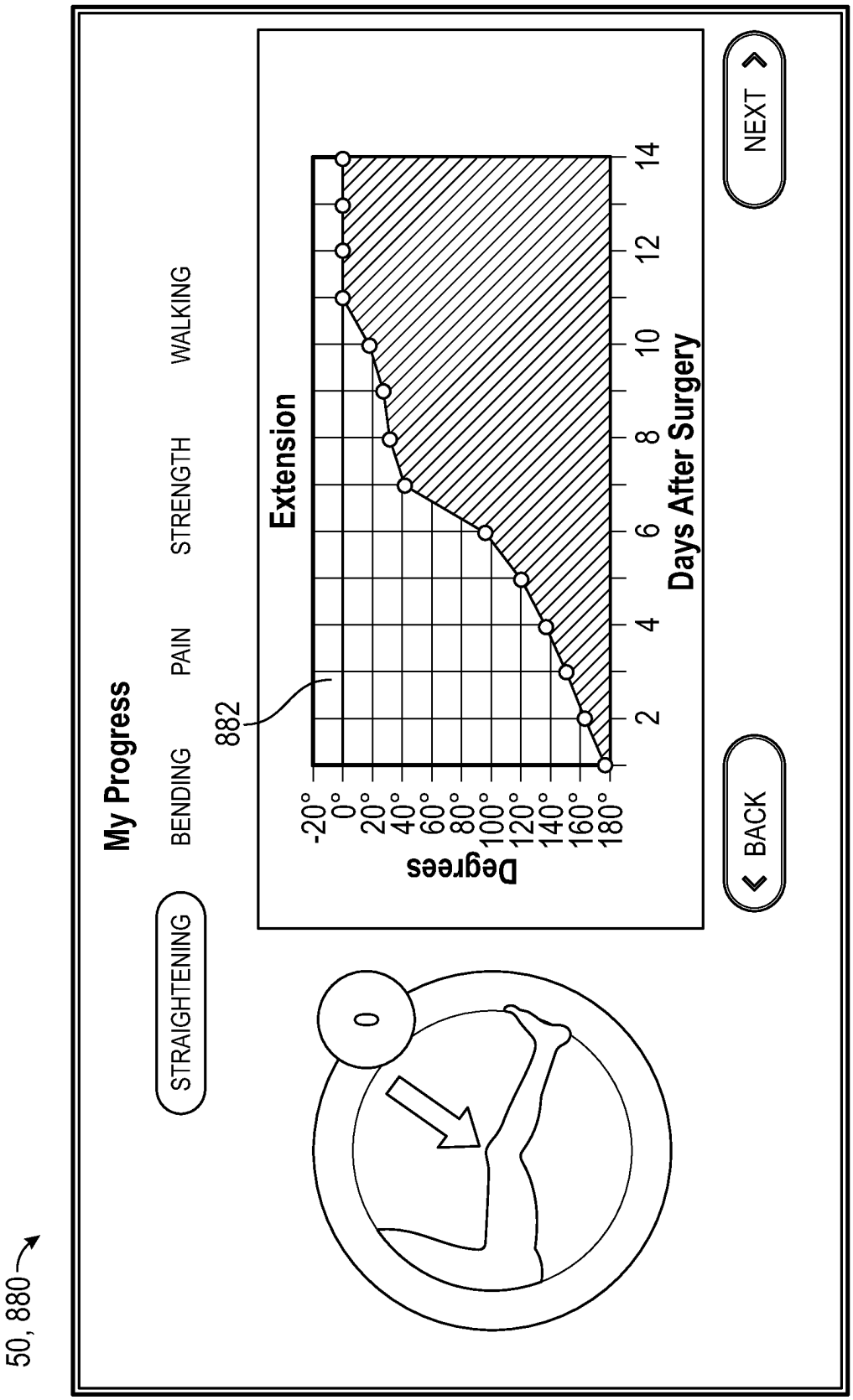
50, 880
My Progress
BENDING
PAIN
STRENGTH
WALKING
STRAIGHTENING
882
Extension
Degrees
-20°
0°
20°
40°
60°
80°
100°
120°
140°
160°
180°
2
4
6
8
10
12
14
Days After Surgery
BACK
NEXT

FIG. 16

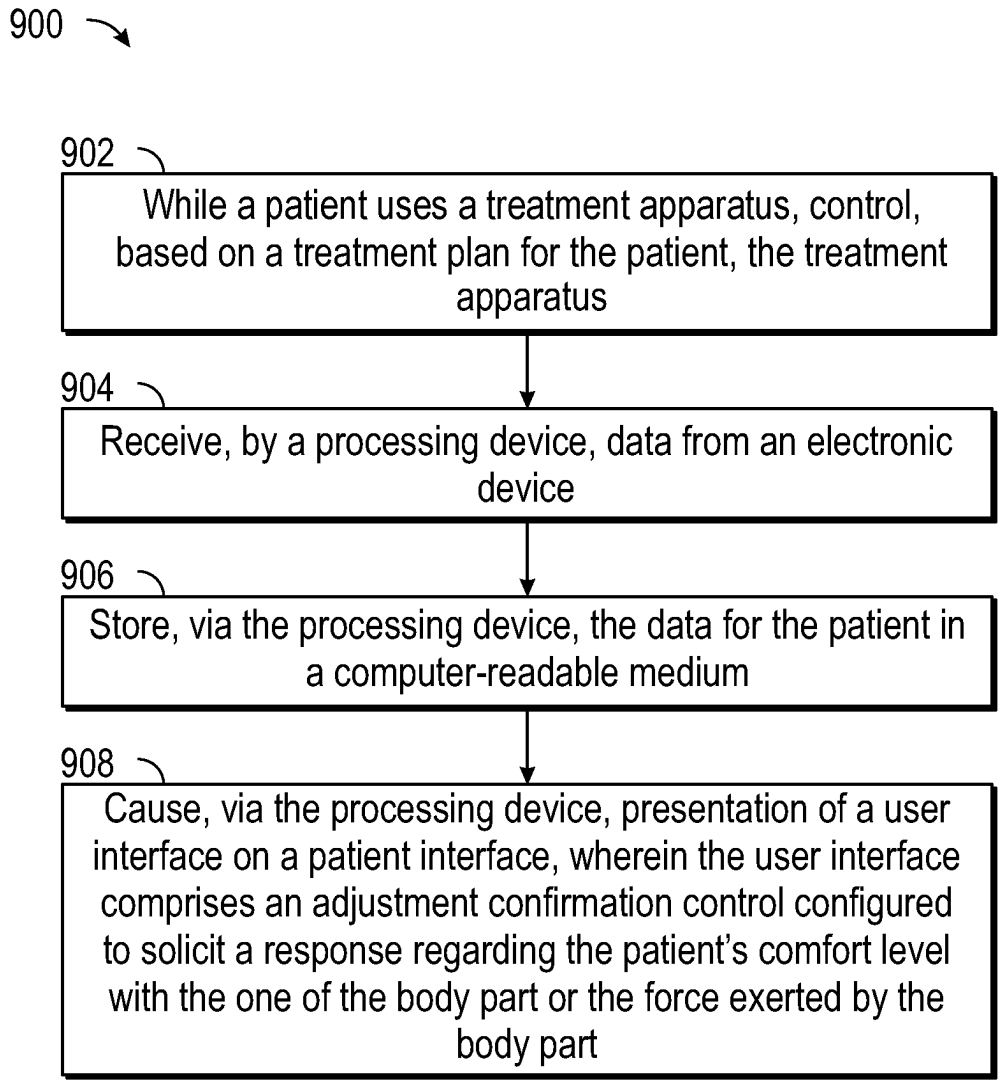
900
902
While a patient uses a treatment apparatus, control, based on a treatment plan for the patient, the treatment apparatus
904
Receive, by a processing device, data from an electronic device
906
Store, via the processing device, the data for the patient in a computer-readable medium
908
Cause, via the processing device, presentation of a user interface on a patient interface, wherein the user interface comprises an adjustment confirmation control configured to solicit a response regarding the patient's comfort level with the one of the body part or the force exerted by the body part

FIG. 17

PERSUASIVE MOTIVATION FOR ORTHOPEDIC TREATMENT

CROSS-REFERENCES TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 17/075,508 filed Oct. 20, 2020, titled "Persuasive Motivation for Orthopedic Treatment," which claims priority to and the benefit of U.S. Provisional Application Patent Ser. No. 62/923,829 filed Oct. 21, 2019, titled "Persuasive Motivation for Orthopedic Treatment," the entire disclosure of which is hereby incorporated by reference for all purposes.

BACKGROUND

Patients may use treatment apparatuses for any suitable purpose, such as rehabilitation of a body part, pre-habilitation of a body part, strengthening a body part, exercising a body part, and the like.

SUMMARY

A method is disclosed. The method includes, while the patient uses the treatment apparatus, controlling, based on a treatment plan for a patient, a treatment apparatus. The method includes receiving, by a processing device, data from an electronic device, wherein the data comprises one of a position of a body part of the patient or a force exerted by the body part. The method includes storing, via the processing device, the data for the patient in a computer-readable medium. The method includes causing, via a processing device, presentation of a user interface on a patient interface. The user interface comprises an adjustment confirmation control, and the adjustment confirmation control is configured to solicit a response regarding the patient's comfort level with the one of the position of the body part or the force exerted by the body part.

A computer-implemented system for physical rehabilitation is provided. The computer-implemented system comprises a clinician interface including a patient profile display configured to present data regarding performance, by a patient, of a regimen for a body part, the body part comprising at least one of a joint, a bone, or a muscle group. The computer-implemented system also comprises a sensor configured to measure one of a position of the body part or a force exerted by the body part. The computer-implemented system also comprises a patient interface including an output device and an input device for communicating information regarding the performance of the regimen, respectively to and from the patient. The patient interface is configured to present instructions and status information to the patient regarding the performance of the regimen. The patient interface is configured to present an adjustment confirmation control configured to solicit a response regarding the patient's comfort or discomfort with the one of the position of the body part or the force exerted by the body part.

A system for remote treatment is also provided. The system for remote treatment comprises: a clinician interface configured to present controls for modifying a treatment plan comprising a regimen for treatment of a body part of a patient, with the body part comprising at least one of a joint, a bone, or a muscle group. The system also comprises a treatment apparatus for performing the regimen upon the body part, the treatment apparatus is configured to be manipulated by the patient. The system also comprises a patient interface including an output device and an input device for communicating information regarding the performance of the regimen, respectively to and from the patient. The patient interface and the treatment apparatus are each configured to enable operation from a patient location geographically separate from a location of the clinician interface. The patient interface is configured to present an adjustment confirmation control configured to solicit a response regarding the patient's comfort level with one of a position of the body part or a force exerted by the body part.

A patient user interface generated by a computer is also provided. The patient user interface comprises a session period action screen configured to present real-time status of a measurement regarding a patient's use of a treatment apparatus for performing a regimen for a body part, the body part comprising at least one of a joint, a bone, or a muscle group. The patient user interface also comprises an adjustment confirmation control configured to solicit a response regarding the patient's comfort level with one of a position of the body part or a force exerted by the body part. The measurement regarding the patient's use of the treatment apparatus includes the one of the position of the body part or the force exerted by the body part.

BRIEF DESCRIPTION OF THE DRAWINGS

For a detailed description of example embodiments, reference will now be made to the accompanying drawings in which:

FIG. **1** shows a block diagram of an embodiment of a computer implemented system for managing a treatment plan;

FIG. **2** shows a perspective view of an embodiment of a treatment apparatus;

FIG. **3** shows a perspective view of a pedal of the treatment apparatus of FIG. **2**;

FIG. **4** shows a perspective view of a person using the treatment apparatus of FIG. **2**;

FIG. **5** shows an example embodiment of an overview display of a clinician interface;

FIG. **6** shows an example embodiment of a patient profile display of a clinician interface;

FIG. **7** shows another view of the example patient profile display of FIG. **6**;

FIG. **8** shows an example embodiment of a treatment protocol management display of a clinician interface;

FIG. **9** shows an example embodiment of a positioning confirmation screen of a patient interface;

FIG. **10** shows an example embodiment of a positioning help screen of a patient interface;

FIG. **11** shows an example embodiment of an adjustment introduction screen of a patient interface;

FIG. **12** shows an example embodiment of an adjustment confirmation screen of a patient interface;

FIG. **13** shows an example embodiment of a session period action screen of a patient interface;

FIG. **14** shows an example embodiment of an exercise introduction screen of a patient interface;

FIG. **15** shows an example embodiment of an exercise action screen of a patient interface; and

FIG. **16** shows an example embodiment of a first progress data screen of a patient interface.

FIG. **17** shows an example method for persuasively motivating a patient to use a treatment apparatus.

NOTATION AND NOMENCLATURE

Various terms are used to refer to particular system components. Different companies may refer to a component

by different names—this document does not intend to distinguish between components that differ in name but not function. In the following discussion and in the claims, the terms "including" and "comprising" are used in an open-ended fashion, and thus should be interpreted to mean "including, but not limited to . . . ." Also, the term "couple" or "couples" is intended to mean either an indirect or direct connection. Thus, if a first device couples to a second device, that connection may be through a direct connection or through an indirect connection via other devices and connections.

The terminology used herein is for the purpose of describing particular example embodiments only, and is not intended to be limiting. As used herein, the singular forms "a," "an," and "the" may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. It is also to be understood that additional or alternative steps may be employed.

The terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections; however, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer, or section from another region, layer, or section. Terms such as "first," "second," and other numerical terms, when used herein, do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer, or section discussed below could be termed a second element, component, region, layer, or section without departing from the teachings of the example embodiments. The phrase "at least one of," when used with a list of items, means that different combinations of one or more of the listed items may be used, and only one item in the list may be needed. For example, "at least one of: A, B, and C" includes any of the following combinations: A, B, C, A and B, A and C, B and C, and A and B and C. In another example, the phrase "one or more" when used with a list of items means there may be one item or any suitable number of items exceeding one.

Spatially relative terms, such as "inner," "outer," "beneath," "below," "lower," "above," "upper," "top," "bottom," and the like, may be used herein. These spatially relative terms can be used for ease of description to describe one element's or feature's relationship to another element(s) or feature(s) as illustrated in the figures. The spatially relative terms may also be intended to encompass different orientations of the device in use, or operation, in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the example term "below" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptions used herein interpreted accordingly.

DETAILED DESCRIPTION

The following discussion is directed to various embodiments of the disclosure. Although one or more of these embodiments may be preferred, the embodiments disclosed should not be interpreted, or otherwise used, as limiting the scope of the disclosure, including the claims. In addition, one skilled in the art will understand that the following description has broad application, and the discussion of any embodiment is meant only to be exemplary of that embodiment, and not intended to intimate that the scope of the disclosure, including the claims, is limited to that embodiment.

FIG. **1** shows a block diagram of a computer-implemented system **10**, hereinafter called "the system" for managing a treatment plan. The treatment plan includes one or more treatment protocols, and each treatment protocol includes one or more sessions. Each session comprises several session periods, with each session period including a particular activity for treating the body part of the patient. For example, a treatment plan for post-operative rehabilitation after a knee surgery may include an initial treatment protocol with twice daily stretching sessions for the first 3 days after surgery and a more intensive treatment protocol with active exercise sessions performed 4 times per day starting 4 days after surgery.

The system **10** includes a clinician interface **20** for a clinician, such as a doctor, a nurse, a physical therapist, or a technician, to use to review and to configure various aspects of a treatment plan for use in treating a patient. The clinician interface **20** includes a clinician input device **22** and a clinician display **24**, which may be collectively called a clinician user interface **22**, **24**. The clinician input device **22** may include one or more of a keyboard, a mouse, a trackpad, or a touch screen, for example. Alternatively or additionally, the clinician input device **22** may include one or more microphones and voice-based functionalities, with hardware and/or software configured to interpret spoken instructions by the clinician by using the one or more microphones. The clinician input device **22** may include functionality provided by or similar to existing voice-based assistants such as Siri by Apple, Alexa by Amazon, Google Assistant, or Bixby by Samsung. The clinician input device **22** may include other hardware and/or software components. The clinician input device **22** may include one or more general purpose devices and/or special-purpose devices.

The clinician display **24** may take one or more different forms including, for example, a computer monitor or display screen on a tablet, smartphone, or a smart watch. The clinician display **24** may include other hardware and/or software components such as a projector, virtual reality capability, or augmented reality capability etc. The clinician display **24** may incorporate various different visual, audio, or other presentation technologies. For example, the clinician display **24** may include a non-visual display, such as an audio signal, which may include spoken language and/or other sounds such as tones, chimes, and/or melodies which may signal different conditions and/or directions. The clinician display **24** may comprise one or more different display screens presenting various data and/or interfaces or controls for use by the clinician. The clinician display **24** may include graphics, which may be presented by a web-based interface and/or by a computer program or application (App.).

The system **10** also includes a server **30** configured to store and to provide data related to managing the treatment plan. The server **30** may include one or more computers and may take the form of a distributed and/or virtualized computer or computers. In some embodiments, the server **30** may generate aspects of the clinician display **24** for presentation by the clinician interface **20**. For example, the server **30** may include a web server configured to generate the display screens for presentation upon the clinician display **24**. In some embodiments, the clinician display **24** may be

configured to present a virtualized desktop that is hosted by the server **30**. The server **30** also includes a first communication interface **32** configured to communicate with the clinician interface **20** via a first network **34**. In some embodiments, the first network **34** may include a local area network (LAN), such as an Ethernet network. In some embodiments, the first network **34** may include the Internet, and communications between the server **30** and the clinician interface **20** may be secured via encryption, such as, for example, by using a virtual private network (VPN). In some embodiments, the first network **34** may include wired and/or wireless network connections such as Wi-Fi, Bluetooth, ZigBee, Near-Field Communications (NFC), cellular data network, etc. The server **30** includes a first processor **36** and a first machine-readable storage memory **38**, which may be called a "memory" for short, holding first instructions **40** for performing the various actions of the server **30** for execution by the first processor **36**. The server **30** is configured to store data regarding the treatment plan. For example, the memory **38** includes a system data store **42** configured to hold system data, such as data pertaining to treatment plans for treating one or more patients. The server **30** is also configured to store data regarding performance by a patient in following a treatment plan. For example, the memory **38** includes a patient data store **44** configured to hold patient data, such as data pertaining to the one or more patients, including data representing each patient's performance within the treatment plan.

The system **10** also includes a patient interface **50** configured to communicate information to a patient and to receive feedback from the patient. Specifically, the patient interface **50** includes an input device **52** and an output device **54**, which may be collectively called a patient user interface **52**, **54**. The input device **52** may include one or more devices, such as a keyboard, a mouse, a touch screen input, a gesture sensor, and/or a microphone and processor configured for voice recognition. The output device **54** may take one or more different forms including, for example, a computer monitor or display screen on a tablet, smartphone, or a smart watch. The output device **54** may include other hardware and/or software components such as a projector, virtual reality capability, augmented reality capability, etc. The output device **54** may incorporate various different visual, audio, or other presentation technologies. For example, the output device **54** may include a non-visual display, such as an audio signal, which may include spoken language and/or other sounds such as tones, chimes, and/or melodies, which may signal different conditions and/or directions. The output device **54** may comprise one or more different display screens presenting various data and/or interfaces or controls for use by the patient. The output device **54** may include graphics, which may be presented by a web-based interface and/or by a computer program or application (App.).

As shown in FIG. **1**, the patient interface **50** includes a second communication interface **56**, which may also be called a remote communication interface configured to communicate with the server **30** and/or the clinician interface **20** via a second network **58**. In some embodiments, the second network **58** may include a local area network (LAN), such as an Ethernet network. In some embodiments, the second network **58** may include the Internet, and communications between the patient interface **50** and the server **30** and/or the clinician interface **20** may be secured via encryption, such as, for example, by using a virtual private network (VPN). In some embodiments, the second network **58** may include wired and/or wireless network connections such as Wi-Fi, Bluetooth, ZigBee, Near-Field Communications (NFC), cellular data network, etc. In some embodiments, the second network **58** may be the same as and/or operationally coupled to the first network **34**.

The patient interface **50** includes a second processor **60** and a second machine-readable storage memory **62** holding second instructions **64** for execution by the second processor **60** for performing various actions of patient interface **50**. The second machine-readable storage memory **62** also includes a local data store **66** configured to hold data, such as data pertaining to a treatment plan and/or patient data, such as data representing a patient's performance within a treatment plan. The patient interface **50** also includes a local communication interface **68** configured to communicate with various devices for use by the patient in the vicinity of the patient interface **50**. The local communication interface **68** may include wired and/or wireless communications. In some embodiments, the local communication interface **68** may include a local wireless network such as Wi-Fi, Bluetooth, ZigBee, Near-Field Communications (NFC), cellular data network, etc.

The system **10** also includes a treatment apparatus **70** configured to be manipulated by the patient and/or to manipulate a body part of the patient for performing activities according to the treatment plan. In some embodiments, the treatment apparatus **70** may take the form of an exercise and rehabilitation apparatus configured to perform and/or to aid in the performance of a rehabilitation regimen, which may be an orthopedic rehabilitation regimen, and the treatment includes rehabilitation of a body part of the patient, such as a joint or a bone or a muscle group. More specifically, the regimen may be a physical rehabilitation regimen for improving strength and/or range of motion of the body part. The body part may include, for example, a spine, a hand, a foot, a knee, or a shoulder. The body part may include a part of a joint, a bone, or a muscle group, such as one or more vertebrae or a ligament. As shown in FIG. **1**, the treatment apparatus **70** includes a controller **72**, which may include one or more processors, computer memory, and/or other components. The treatment apparatus **70** also includes a fourth communication interface **74** configured to communicate with the patient interface **50** via the local communication interface **68**. The treatment apparatus **70** also includes one or more internal sensors **76** and an actuator **78**, such as a motor. The actuator **78** may be used, for example, for moving the patient's body part and/or for resisting forces by the patient.

The internal sensors **76** may measure one or more operating characteristics of the treatment apparatus **70** such as, for example, a force a position, a speed, and/or a velocity. In some embodiments, the internal sensors **76** may include a position sensor configured to measure at least one of a linear motion or an angular motion of a body part of the patient. For example, an internal sensor **76** in the form of a position sensor may measure a distance that the patient is able to move a part of the treatment apparatus **70**, where such distance may correspond to a range of motion that the patient's body part is able to achieve. In some embodiments, the internal sensors **76** may include a force sensor configured to measure a force applied by the patient. For example, an internal sensor **76** in the form of a force sensor may measure a force or weight the patient is able to apply, using a particular body part, to the treatment apparatus **70**.

The system **10** shown in FIG. **1** also includes an ambulation sensor **82**, which communicates with the server **30** via the local communication interface **68** of the patient interface **50**. The ambulation sensor **82** may track and store a number

of steps taken by the patient. In some embodiments, the ambulation sensor **82** may take the form of a wristband, wristwatch, or smart watch. In some embodiments, the ambulation sensor **82** may be integrated within a phone, such as a smartphone.

The system **10** shown in FIG. **1** also includes a goniometer **84**, which communicates with the server **30** via the local communication interface **68** of the patient interface **50**. The goniometer **84** measures a position of the patient's body part. More specifically, the goniometer **84** measures an angle of the body part, particularly where the body part is a joint. For example, the goniometer **84** may measure the angle of flex of a patient's knee or elbow or shoulder.

The system **10** shown in FIG. **1** also includes a pressure sensor **86**, which communicates with the server **30** via the local communication interface **68** of the patient interface **50**. The pressure sensor **86** measures an amount of pressure or weight applied by a body part of the patient. For example, pressure sensor **86** may measure an amount of force applied by a patient's foot when pedaling a stationary bike.

The system **10** also includes a wearable device **90** configured to be worn or carried on the patient's person. The wearable device **90** may take one of several different forms such as, for example, a smart watch, a wristband, a pendant, or a smartphone. The wearable device **90** may include a means of attachment, such as a pin, a belt clip, a strap, or a lanyard, to facilitate the device's being worn or carried by the patient. In some embodiments, and as shown in FIG. **1**, the wearable device **90** includes the ambulation sensor **82**. The wearable device **90** may include one or more other sensors, such as a heartrate sensor, a blood pressure sensor, or a pulse oximeter. The ambulation sensor **82** or another one of the sensors in the wearable device **90** may be configured to monitor one or more factors that indicate an activity level of the patient. The patient's activity level could be used to determine a quantity and/or quality of exercise performed by the patient. The patient's activity level could also be used to determine a quantity and/or quality of the patient's sleep.

The wearable device **90** includes a wearable input device **92** and a wearable display **94**, which may be collectively called a wearable user interface **92**, **94**. The wearable input device **92** may include one or more devices, such as a keyboard, a mouse, a touch screen input, a gesture sensor, and/or a microphone and processor configured for voice recognition. The wearable display **94** may take one or more different forms including, for example, a display screen, and/or one or more lights or other indicators. The wearable display **94** may incorporate various different visual, audio, or other presentation technologies. For example, the wearable display **94** may include a non-visual display, such as a haptic or tactile device and/or an audio signal, which may include spoken language and/or other sounds such as tones, chimes, and/or melodies, and the non-visual display may signal different conditions and/or directions. The wearable display **94** may comprise one or more different display screens configured to present various data and/or interfaces or controls for use by the patient. The wearable display **94** may include graphics, which may be presented by a web-based interface and/or by a computer program or application (App.). The wearable user interface **92**, **94** may be configured to present different types of information to the patient. For example, the wearable user interface **92**, **94** may be configured to present a reminder when it is time for the patient to perform a rehabilitation session. The wearable user interface **92**, **94** may allow the patient to track daily goals or to receive messages from a clinician, etc. This function of the wearable device **90** may be especially useful when the patient is away from the patient interface **50**.

The system **10** shown in FIG. **1** also includes a supervisory interface **96** which may be similar or identical to the clinician interface **20**. In some embodiments, the supervisory interface **96** may have enhanced functionality beyond what is provided on the clinician interface **20**. The supervisory interface **96** may be configured for use by a person having responsibility for the treatment plan, such as an orthopedic surgeon.

The system **10** shown in FIG. **1** also includes a reporting interface **98** which may be similar or identical to the clinician interface **20**. In some embodiments, the reporting interface **98** may have less functionality from what is provided on the clinician interface **20**. For example, the reporting interface **98** may not have the ability to modify a treatment plan. Such a reporting interface **98** may be used, for example, by a biller to determine the use of the system **10** for billing purposes. In another example, the reporting interface **98** may not have the ability to display patient identifiable information, presenting only pseudonymized data and/or anonymized data for certain data fields concerning a data subject and/or for certain data fields concerning a quasi-identifier of the data subject. Such a reporting interface **98** may be used, for example, by a researcher to determine various effects of a treatment plan on different patients.

In some embodiments, the patient interface **50** and the treatment apparatus **70** are each configured to operate from a patient location geographically separate from a location of the clinician interface **20**. For example, the patient interface **50** and the treatment apparatus **70** may be used as part of an in-home rehabilitation system, which may be monitored remotely by using the clinician interface **20** at a centralized location, such as a clinic or hospital. In some embodiments, either or both of the patient interface **50** and/or the treatment apparatus **70** are configured to communicate with a remote computer, such as the server **30**, to receive the treatment plan and to report back to the remote computer with data regarding performance by the patient in following the treatment plan.

FIGS. **2-3** show an embodiment of a treatment apparatus **70**. More specifically, FIG. **2** shows a treatment apparatus **70** in the form of a stationary cycling machine **100**, which may be called a stationary bike, for short. The stationary cycling machine **100** includes a set of pedals **102** each attached to a pedal arm **104** for rotation about an axle **106**. In some embodiments, and as shown in FIG. **2**, the pedals **102** are movable on the pedal arms **104** in order to adjust a range of motion used by the patient in pedaling. For example, the pedals being located inwardly toward the axle **106** corresponds to a smaller range of motion than when the pedals are located outwardly away from the axle **106**. A pressure sensor **86** is attached to or embedded within one of the pedals **106** for measuring an amount of force applied by the patient on the pedal **106**. The pressure sensor **86** may communicate wirelessly to the treatment apparatus **70** and/or to the patient interface **50**.

FIG. **4** shows a person (a patient) using the treatment apparatus of FIG. **2**, and showing sensors and various data parameters connected to a patient interface **50**. The example patient interface **50** is a tablet computer or smartphone, or a phablet, such as an iPad, an iPhone, an Android device, or a Surface tablet, which is held manually by the patient. In some other embodiments, the patient interface **50** may be embedded within or attached to the treatment apparatus **70**. FIG. **4** shows the patient wearing the ambulation sensor **82**

on his wrist, with a note showing "STEPS TODAY 1355", indicating that the ambulation sensor **82** has recorded and transmitted that step count to the patient interface **50**. FIG. **4** also shows the patient wearing the goniometer **84** on his right knee, with a note showing "KNEE ANGLE 72°", indicating that the goniometer **84** is measuring and transmitting that knee angle to the patient interface **50**. FIG. **4** also shows a right side of one of the pedals **106** with a pressure sensor **86** showing "FORCE 12.5 lbs.," indicating that the right pedal pressure sensor **86** is measuring and transmitting that force measurement to the patient interface **50**. FIG. **4** also shows a left side of one of the pedals **106** with a pressure sensor **86** showing "FORCE 27 lbs.", indicating that the left pedal pressure sensor **86** is measuring and transmitting that force measurement to the patient interface **50**. FIG. **4** also shows other patient data, such as an indicator of "SESSION TIME 0:04:13", indicating that the patient has been using the treatment apparatus **70** for 4 minutes and 13 seconds. This session time may be determined by the patient interface **50** based on information received from the treatment apparatus **70**. FIG. **4** also shows an indicator showing "PAIN LEVEL 3". Such a pain level may be obtained from the patent in response to a solicitation, such as a question, presented upon the patient interface **50**.

FIG. **5** is an example embodiment of an overview display **120** of the clinician interface **20**. Specifically, the overview display **120** presents summary information regarding each of a plurality of different patients. In some embodiments, and as shown on FIG. **5**, the summary information includes an indicator showing a procedure performed upon each of the patients, temporal progress of the patient within the treatment plan (post-op day), an indicator of a last-reported pain level, range-of-motion (ROM) numbers, and an indicator showing if there are any alerts requiring special attention.

FIGS. **6-7** show an example embodiment of a patient profile display **130** of the clinician interface **20**. The example patient profile display **130** includes a patient summary **132** with the patient's name, date of birth (DOB), age, a description of a procedure performed or to be performed on the patient, e.g., "Knee surgery", and a picture of the patient, if available. The example patient profile display **130** also includes a treatment progress summary **134**, showing one or more indicators of progress within a treatment regimen or plan. The example treatment progress summary **134** shown on FIG. **6** includes textual progress summaries, "DAY 18", "3 days remaining", "12/63 DAILY SESSIONS COMPLETED", as well as graphical progress summaries in the form of horizontal bar graphs, which may also be called progress bars.

The example patient profile display **130** presents information regarding a treatment history of the patient. For example, the example patient profile display **130** includes a plurality of different treatment graphs **136** showing the effect of various treatment parameters over time. The treatment graphs **136** shown in the example patient profile display **130** of FIGS. **6-7** include extension (angle), flexion (angle), pain (0-10 scale), ambulation (steps/day), and total revolutions (i.e., revolutions performed on the stationary cycling machine **100**). The patient profile display **130** shown on FIG. **7** also includes a pictorial history **138**, showing one or more images of the surgical site for reference by a clinician or other healthcare professional in reviewing post-operative progress. The images in the pictorial history **138** may be taken by the patient and/or by a clinician or other healthcare professional. For example, the first picture may be taken by a member of the surgical staff, and subsequent pictures may be taken by the patient and/or the rehabilitation clinician.

The example patient profile display **130** shown on FIG. **7** also includes a protocol summary display **140** showing a summary overview of a treatment protocol to be performed by the patient. The example protocol summary display **140** includes a protocol heading **142** with a protocol name, e.g. "Acute Protocol." The protocol heading **142** also includes overview information regarding how and when the protocol is to be performed, e.g. "Days 1-14, 3 sessions daily." The protocol summary display **140** also includes several protocol session icons **144**, each indicating details of an activity to be performed within a protocol session, e.g., "Passive", "Active", or "Resistance", together with other information regarding the protocol session, such as a direction (forward/reverse), and an amount of time that each protocol session is prescribed to be performed.

FIG. **8** shows an example embodiment of a protocol management display **170** of a clinician interface **20** for editing a treatment protocol **156**. Specifically, the protocol management display **170** includes a protocol name control **172** for renaming the treatment protocol **156**. The protocol management display **170** also includes a protocol timing control **174** for adjusting various timing settings of the treatment protocol **156**, such as a duration for the treatment protocol **156** within the treatment plan **152**, and a number of sessions to be performed per day. The example protocol timing control **174** shown on FIG. **8** includes drop-down menus for changing the various timing settings, but other controls could be used such as, for example, numeric entry fields or increase/decrease buttons. The protocol management display **170** also includes a protocol session control **176** for customizing the session periods. Specifically, the protocol session control **176** includes a graphical representation of a session, with protocol session icons **144**, which may be similar or identical to the protocol session icons **144** of the protocol summary display **140**. Each session period may have an associated type, such as passive, resistance, assisted, or active. Each session period may also have several parameters associated therewith.

The protocol session control **176** allows the clinician to adjust the number, the order, and the types of the session periods within a given session of the treatment protocol **156**. Each session period has a type that corresponds to a category of activity to be performed upon a body part during that session period. For example, the session periods may be one of a passive period, an assisted period, an active period, or a resistance period. Each passive period is associated with a particular activity that includes moving a body part by an external force; each assisted period is associated with a particular activity that includes moving the body part by the patient with assistance of the external force; each active period is associated with a particular activity that includes the patient moving the body part without assistance of the external force; and each resistance period is associated with a particular activity that includes the patient actively moving the body part against a resistance force. For example, where the treatment apparatus **70** includes a stationary cycling machine **100**, a passive period may include an actuator **78**, such as a motor, that rotates the pedals **108** with the patient's feet and legs attached thereto and without any action or force being applied by the patient. An assisted period may include the patient applying force to rotate the pedals **108** with some additional help or assistance from the actuator **78**. An active period may include the patient applying force to rotate the pedals **108** without any assistance from any outside force. A resistance period may include the patient exerting some force to rotate the pedals **108** in opposition to a resistance force applied by the actuator **78**. In some embodiments, the

actuator **78** may produce the external forces for each of the different categories of the session periods. The external forces may have different attributes, such as directions, intensities, or rates of changes, for each of the different categories of the session periods. Each session may include any number of session periods in any combination.

In some embodiments, the protocol session icons **144** may be modified using a drag-and-drop interface. Additional protocol sessions may be added to the protocol session using a session period control **177**. Additionally, parameters for any or all of the session periods may be adjusted using various session parameter controls **178**. For example, a duration and direction of each session period may be adjusted using the session parameter controls **178** located below an associated one of the protocol session icons **144**. Various other parameters, such as resistance, target speed range (RPM), pedal radius limits, etc. may be adjusted using other session parameter controls **178**. In some embodiments, the number and the type of session parameter controls **178** may change depending on the type of session period selected. For example, selecting a protocol session icon **144** for an active type of session period may cause the target speed range (RPM) session parameter control **178** to be visible and adjustable, but the target speed range (RPM) session parameter control **178** may not be visible and/or adjustable in response to selecting a protocol session icon **144** for a passive type session.

In some embodiments, the system **10** may impose limits on values that can be set using the session parameter controls **178**. For example, the treatment plan **154** may include a maximum session time. In some embodiments, to satisfy a rule of the system **10** or a rule within the treatment plan **154**, one or more of the values of the parameters may be automatically changed by the system **10**. For example, the treatment plan **154** may require a resistance type of session period after an active type of session period, wherein the former is at least 25% as long as the active type of session to allow the patient to cool down after active exercise. The system **10** may automatically create the resistance type session period in response to the clinician creating an active type session period. The system **10** may also automatically adjust the time of the resistance type session period to satisfy the requirement of it lasting at least 25% as long as the active type of session.

In some embodiments, the treatment plan **154** may include maximum values for certain parameters until an associated condition is satisfied. For example, the pedal radius limit may be limited to 40 mm until an associated condition is satisfied. Associated conditions may include, for example, approval by an authorized person, such as an orthopedic surgeon; the elapsing of a particular time, such as 5 days after a surgical procedure; or successful completion of a post-operation checkup. Similarly, the treatment plan **154** may place limits on the types of session periods that may be performed until an associated condition is satisfied. The treatment plan **154** may be limited to only passive or assisted session periods (and not active periods or resistance periods until an associated condition is satisfied. Different associated conditions may be associated with each of the different parameters and/or with limits on the types of session periods available.

FIG. **9** shows an example embodiment of positioning confirmation screen **520** of the patient interface **50**. This screen **520** is the beginning of a guided walk-through for the patient to use the treatment apparatus **70**. Specifically, this screen **520** includes written instructions to guide the patient in placing their feet in the pedals **102** of a stationary cycling machine **100**. In some embodiments, this screen **520** may include graphics, such as pictures or animations to help the patient perform particular actions for using the treatment apparatus **70**. Screen **520** includes a position confirmation selector **522** for the patient to indicate that they are in position to use the treatment apparatus **70**. Screen **520** also includes a trouble button **524** for the patient to indicate that they are having trouble getting in position to use the treatment apparatus **70**.

FIG. **10** shows an example embodiment of a positioning help screen **560** of the patient interface **50**. This help screen **560** may be shown in response to the user selecting the trouble button **524** on the positioning confirmation screen **520**. The help screen **560** may automatically be displayed if the patient fails to select the position confirmation selector **522** within a predetermined period of time. In some embodiments, an intermediate screen such as a popup asking if the patient needs more time may be displayed before the help screen **560** is shown. The help screen **560** includes assistance instructions **562** for the patient to obtain assistance for using the treatment apparatus **70**. In some embodiments, the assistance instructions **562** may include a phone number. The assistance instructions **562** may also include other items, such as a link to a video conference with someone able to help the patient, and/or a link to a video or animated walk-through with detailed instructions for performing a particular action to use the treatment apparatus **70**. The particular action may include, for example, placing the feet in the pedals. The help screen **560** may also include an exit button **564** that the patient can use to stop the treatment session in case they are unable to resolve their issue with using the treatment apparatus **70**. Use of the exit button **564** may generate an alert to the clinician. The help screen **560** also includes a proceed button **566** that the patient can use to indicate that they have resolved their issue and are able to proceed with the treatment session.

FIG. **11** shows an example embodiment of an adjustment introduction screen **680** of the patient interface **50**. The adjustment introduction screen **680** includes text and/or graphics indicating various adjustments to be performed by the treatment apparatus **70**. In the example shown, the adjustments include the treatment apparatus **70** that is a stationary cycling machine **100** that automatically moves the pedals **102** outwardly to a predetermined position for the session period.

In some embodiments, the patient interface **50** presents an adjustment confirmation control configured to solicit a response regarding the patient's comfort level with the position of the body part or the force exerted by the body part. The comfort level may be indicated by a binary selection (e.g., comfortable or not comfortable). In some embodiments, the comfort level may be an analog value that may be indicated numerically or with an analog input control, such as a slider or a rotary knob. In some embodiments, the comfort level may be indicated by one of several different comfort level values, such as an integer number from 1 to 5. In some embodiments, the comfort level may be indicated using controls for the patient to maintain a setting or for the patient to change the setting. More specifically, the adjustment confirmation control for the patient to change the setting may provide for the patient to change the setting in either of two or more directions. For example, the controls may allow the patient to maintain the value of a setting, to increase the value of the setting, or to decrease the value of the setting.

In some embodiments, the patient interface **50** and/or a server may generate and/or present the adjustment confir-

mation control using one or more machine learning models. The one or more machine learning models may be trained using training data including inputs that are mapped to outputs, such that the machine learning models identify patterns in the data to generate a certain output. The training data may include input data of types and/or arrangements of graphical user interface elements to present that are associated with a higher likelihood of a patient providing feedback. The training data may include input data of values of comfort levels to present that are associated with a higher likelihood of a patient providing feedback. The training data may include input data of values of positions of body parts to present that are associated with a higher likelihood of a patient providing feedback.

The adjustment confirmation control may take the form of an adjustment confirmation screen **720**, as shown, for example, in FIG. **12**. The adjustment confirmation control may take other forms, such as a popup window or a portion of a larger display screen. The patient interface **50** may present the adjustment confirmation control on a graphical user interface, such as a display screen or an overlay or virtual control within a virtual reality (VR) or augmented reality (AR) display. Additionally or alternatively, the adjustment confirmation control may include one or more physical control devices, such as buttons, knobs, sliders, etc. In some embodiments, the adjustment confirmation control may be used in conjunction with an automatic adjustment, such as an actuator **78** within the treatment apparatus **70**. For example, as shown in the FIGS., an actuator **78** may change the radius of one of the pedals **102**, thus changing the position of the patient's knees. The adjustment confirmation control may then solicit a response regarding the patient's comfort or discomfort with the adjusted position. In another example, the patient interface **50** may prompt the patient to apply a target pressure, such as 50 lbs. The adjustment confirmation control may then solicit a response regarding the patient's comfort or discomfort in applying the target pressure.

The phrase "ICON" refers to 'increase control', the phrase "DCON" refers to 'decrease control', and the phrase "SCON" refers to 'stay control', unless explicitly stated otherwise, are intended to be understood as noun phrases meaning controls that serve the functions of increasing, decreasing, or maintaining corresponding values.

The adjustment confirmation screen **720** includes text and/or graphics requesting the patient to confirm their satisfaction with the position of the treatment apparatus **70** during and/or after the automatic adjustments are made. The adjustment confirmation screen **720** includes an increase control that the patient may select to indicate a desire to increase the value of a corresponding parameter. The corresponding parameter may be a position of the treatment apparatus **70** such as the radius of the pedal **102** on the pedal arm **104**. The corresponding parameter may be a setting for a force or a speed of an exercise performed as part of the regimen. For example, the corresponding parameter may be a target pressure or a target RPM speed in a given session period. The increase control may take the form of an increase button **722**, such as the button shown on FIG. **12**. The increase control may take other forms, such as a knob or slider control, which may be a physical device or part of a graphical user interface. The adjustment confirmation screen **720** also includes a stay control that the patient may select to indicate a desire to maintain the value of the corresponding parameter. The stay control may take the form of a stay button **724**, such as the button shown on FIG. **12**. The stay control may take other forms, such as a knob or slider control, which may be a physical device or part of a graphical user interface. The adjustment confirmation screen **720** also includes a decrease control that the patient may select to indicate a desire to decrease the value of the corresponding parameter. The decrease control may take the form of a decrease button **726** such as the button shown on FIG. **12**. The decrease control may take other forms, such as a knob or slider control, which may be a physical device or part of a graphical user interface. For example, if the patient experiences pain or discomfort with the initial position, he or she may change the position using the decrease button **726** until the pain or discomfort is alleviated.

In some embodiments, one or more of the increase, the decrease, and/or the stay control(s) may be provided by one or more of the sensors **76**, **84**, **86**. For example, the patient interface **50** may prompt the patient to move a body part until they start to feel discomfort, the system **10** may use one or more of the sensors **76**, **84**, **86** to measure the range of motion that the body part moved, and that range of motion may be used for performing the rehabilitation regimen. In another example, one or more of the sensors **76**, **84**, **86**, such as a pressure sensor **76** and/or a goniometer **84**, may measure a physical response by the patient, such as a flinch that indicates pain. A target value of the parameter may be set based upon the value of the parameter where the patient indicated pain or discomfort. That target value of the parameter may then be used for performing the rehabilitation regimen. The target value of the parameter may be set based upon a value of the parameter where the patient indicated pain or discomfort. The target parameter value may be set to X % of P, where X is a predetermined percentage, and P is the value of the parameter where the patient indicated pain or discomfort. For example, if a patient indicated pain at a pedal radius of 6.0 cm, and X is 90%, the target parameter value for the pedal position may be set to 5.4 cm, or 90% of 6.0 cm. Alternatively, the target parameter value may be set using an offset value that is added or subtracted from the value of the parameter where the patient indicated pain or discomfort. For example, if a patient indicated pain at pedal radius of 8.0 cm, and the offset value is −1.2 cm, then the target parameter value for the pedal radius may be set to 6.8 cm. Values of other parameters, such as target pressure or target speed, may be similarly adjusted.

In some embodiments, the system **10** may be configured to persuasively motivate the patient to use one or more settings for the position of the body part and/or the force exerted by the body part. For example, the patient interface **50** may show a target value or a target range for the position of the body part and/or the force exerted by the body part. In another example, the patient interface **50** may periodically encourage the patient to increase a setting for the position of the body part and/or the force exerted by the body part, particularly where that setting is below a target value or a target range. The system **10** may gradually increase a setting for the position of the body part and/or the force exerted by the body part while the patient is using the body part to perform the rehabilitation regimen. In some embodiments, the adjustment confirmation control may be presented to the patient only after the setting for the position of the body part and/or the force exerted by the body part has been actively used in performing the rehabilitation regimen for some period of time. In some embodiments, the adjustment confirmation control may not be presented to the patient, even after the setting for the position of the body part and/or the force exerted by the body part is adjusted.

In some embodiments, the patient interface **50** may present the adjustment confirmation control before the patient

performs the rehabilitation regimen. Such a pre-performance adjustment allows the patient to use a confirmed or adjusted position and/or force setting while performing the rehabilitation regimen. Additionally or alternatively, the patient interface **50** may present the adjustment confirmation control during and/or after the rehabilitation regimen. For example, the adjustment confirmation screen **720** may be presented to the patient during a session or between sessions of the rehabilitation regimen. In some embodiments, the adjustment confirmation control may be presented in response to a triggering event. The triggering event may include, for example, the patient reporting pain in excess of a given value, or an inability to complete one or more activities within the treatment plan **154**, or a sudden decrease in walking performed by the patient. Additionally or alternatively, the adjustment confirmation screen **720** may be presented to the patient after the patient has completed a session of the rehabilitation regimen. Such a post-session confirmation may be used to determine the patient's comfort, which may be a proxy for satisfaction with the session of the rehabilitation regimen. The post-session confirmation may be used to determine one or more settings for use in subsequent sessions. For example, an indication of "stay" or "increase" may cause a target value for position and/or pressure of the body part to be increased in subsequent sessions of the rehabilitation regimen.

FIG. **13** shows an example embodiment of a session period action screen **760** of the patient interface **50**. This screen **760** is displayed while a given session period is in progress. It includes one or more indicators showing real-time status of measurements regarding the patient's use of the treatment apparatus **70** to perform the rehabilitation regimen upon patient's body part. The measurements displayed may include, for example, a position of, and/or a force exerted by, the patient's body part. The example session period action screen **760** of FIG. **13** includes pressure indicators **762** showing an amount of pressure or force applied by each foot. The pressure indicators **762** show the pressures of the patient's feet upon the pedals **106** as measured by the pressure sensors **86**. The pressure indicators **762** are shown as bar graphs, but other types of displays may be used, such as rotary gauges and/or numeric indicators. The pressure indicators **762** may also include a target pressure indicator **764** representing a target setting such as a target pressure value. The target setting may be determined by the clinician using an associated session parameter control **178** on the protocol management display **170**, as shown, for example, on FIG. **8**. The target setting may be set or adjusted via the adjustment confirmation control, by the patient.

In some embodiments, the clinician interface **20** may present information regarding the position of the body part and/or the force exerted by the body part. This information may include actual and/or target positions and/or forces as measured by one or more of the sensors **76**, **84**, **86**. Additionally or alternatively, the information regarding the position of the body part and/or the force exerted by the body part may include a target value or a target range of values for either or both of the position of the body part and/or the force exerted by the body part. For example, the clinician interface **20** may provide a control for the clinician to adjust a value or a range of values as a target for a parameter such as a position, a force, or a speed used in a session or a session period or for a particular exercise within the rehabilitation regimen. Similarly, the clinician interface **20** may provide a control for the clinician to adjust minimum and/or maximum values for the parameter. For example, the patient may adjust the value of a pedal radius parameter from the preset target value up to the maximum value for that parameter, where the preset target value and the maximum value are both set by the clinician using corresponding controls on the clinician interface **20**.

The session period action screen **760** also includes a speed indicator **766** showing a speed that the pedals **106** are turning, as measured by an internal sensor **76** of the stationary cycling machine **100**. The speed indicator **766** is shown as a rotary gauge, but other types of displays may be used, such as a bar graph and/or a numeric indicator. The speed indicator **766** includes an optimal or desired speed range, which may be determined by the clinician using an associated session parameter control **178** on the protocol management display **170**, as shown, for example, on FIG. **8**. The session period action screen **760** may present prompts or messages **768** to enable the user to change the pressure and/or speed if either of those parameters is outside of a predetermined range.

FIG. **14** shows an example embodiment of an exercise introduction screen **800** of the patient interface **50**. The exercise introduction screen **800** includes instructions and/or prompts for the patient to perform an exercise that is not performed using the treatment apparatus **70**. In the example shown on FIG. **14**, the exercise involves straightening the patient's leg. FIG. **15** shows an example embodiment of an exercise action screen **840** of the patient interface **50**. The exercise action screen **840** includes a countdown timer **842** showing an amount of time that the patient should continue with a given exercise. The exercise action screen **840** also includes an angle display **844** showing an angle of a body part being exercised. The angle display **844** may show, for example, a knee flex angle measured by the goniometer **84** that is attached to the patient's knee.

FIG. **16** shows an example progress data screen **880** of the patient interface **50**. The progress data screen **880** presents a progress graph **882** for each of several different parameters related to the treatment plan **154**. For example, the progress graphs **882** may include historical data for straightening and bending of the knee pain, strength (lbs. pressure), and walking (steps per day). The progress graphs **882** may show identical data or data similar to what is presented on the treatment parameter graphs **136** of the clinician interface **20**.

In some embodiments, a computer, such as the server **30**, is configured to automatically modify the treatment plan **154** in response to satisfaction by the patient of a predetermined condition. For example, the treatment plan **154** may be limited in speed, velocity, or pressure settings or number of sessions per day until a predetermined condition is satisfied. In another example, the treatment plan **154** may include only certain types of session periods, such as passive type exercises, until the predetermined condition is satisfied. The predetermined condition may include, for example, a successful post-operative checkup; or completion of a predetermined number of sessions or satisfying a performance benchmark within the treatment plan. Such a benchmark may include, for example, walking X number of steps in a day, or some given RPM speed or a given number of pounds of force using the treatment apparatus **70**. In some embodiments, the computer is configured to increase at least one of a frequency, a duration, or an intensity of an aspect of the treatment plan **154** in response to performance or occurrence of the predetermined condition. In some embodiments, the computer is configured to decrease at least one of a frequency, a duration, or an intensity of an aspect of the treatment plan **154** in response to a performance or occurrence of the condition. The predetermined condition may

include, for example, the patient reporting pain in excess of a given value, or an inability to complete one or more activities within the treatment plan **154**, or a sudden decrease in walking performed by the patient.

In some embodiments, the patient interface **50** may provide a prompt to the patient in response to occurrence of the predetermined condition. For example, in a session period where the patient is expected to maintain the stationary cycling machine at a speed of between 40 and 50 RPM, the predetermined condition may include the cycling machine operating below 30 RPM for a period of 5 seconds. In that case, the patient interface **50** may provide a prompt asking the patient if they are having trouble or pain in performing the activity. The prompts may narrow down a problem. For example, if the patient is unable to perform a given activity, then a computer, such as the server **30**, may automatically modify the treatment plan **154** to include activities that are easier for the patient to complete, such as only passive or only assisted session periods. Alternatively, the treatment plan **154** may be suspended until the clinician or another qualified person, such as an orthopedic surgeon, directs the system **10** to re-enable the treatment plan **154**. Additionally or alternatively, the patient's responses to the prompts may generate an alert to the clinician.

In some embodiments, the system may communicate an alert message to the clinician using a communication message, such as a pager message or a text message or an email. The alert message may include pseudonymized data and/or anonymized data or use any privacy enhancing technology to prevent confidential patient data from being communicated in a way that could violate patient confidentiality requirements. Such privacy enhancing technologies may enable compliance with laws, regulations, or other rules of governance such as, but not limited to, the Health Insurance Portability and Accountability Act (HIPAA), or the General Data Protection Regulation (GDPR), wherein the patient may be deemed a "data subject". For example, an alert message may direct the clinician that a particular type of alert exists, such as a patient reporting wound splitting, without identifying which patient made the report. The alert message may direct the clinician to check the clinician interface **20** for more specific details regarding the alert.

According to further aspects, the computer-implemented system **10** may be configured to automatically modify one or more parameters of the treatment plan based upon progress made by the patient in performing the treatment plan. For example, the server **30** may be configured to adjust one or more settings, such as frequency of sessions, a range of motion setting, and/or a pressure setting based on how the patient is progressing in the treatment plan. In some embodiments, the parameters available to be modified by the system may be adjusted within a corresponding range of values set by the clinician. For example, the clinician interface **20** may present one or more controls for the clinician to set a range of values that the system can use for each of the adjustable parameters. The system **10** may use an algorithm to add more sessions (e.g., if the patient is behind schedule). Alternatively, the system **10** may accelerate ahead to more difficult sessions if the recovery is proceeding faster than expected.

FIG. **17** shows an example method **1700** for persuasively motivating a patient to use a treatment apparatus **70**. The method **1700** is performed by processing logic that may include hardware (circuitry, dedicated logic, etc.), software (such as is run on a general-purpose computer system or a dedicated machine), or a combination of both. The method **1700** and/or each of its individual functions, routines, other methods, scripts, subroutines, or operations may be performed by one or more processors of a computing device (e.g., any component referenced in any of the FIGS., such as interfaces, servers, treatment apparatuses, sensors, etc.). In certain implementations, the method **1700** may be performed by a single processing thread. Alternatively, the method **1700** may be performed by two or more processing threads, each thread implementing one or more individual functions or routines; or other methods, scripts, subroutines, or operations of the methods.

For simplicity of explanation, the method **1700** is depicted and described as a series of operations. However, operations in accordance with this disclosure can occur in various orders and/or concurrently, and/or with other operations not presented and described herein. For example, the operations depicted in the method **1700** may occur in combination with any other operation of any other method disclosed herein. Furthermore, not all illustrated operations may be required to implement the method **1700** in accordance with the disclosed subject matter. In addition, those skilled in the art will understand and appreciate that the method **1700** could alternatively be represented as a series of interrelated states via a state diagram, a directed graph, a deterministic finite state automaton, a non-deterministic finite state automaton, a Bayesian model, a Markov diagram, or an event diagram.

At **1702**, while the patient uses a treatment apparatus **70**, the processing device may control, based on a treatment plan for a patient, the treatment apparatus **70**. In some embodiments, the processing device may be separate from the treatment apparatus **70**. For example, the processing device may be included in the patient interface, in a server, in the clinician interface, in any other interface discussed herein, in a sensor, in a computing device, or the like. In some embodiments, the processing device may be included in the treatment apparatus **70**. In some embodiments, the treatment plan is a physical rehabilitation regimen for improving strength or range of motion of a body part.

At **1704**, the processing device may receive data from an electronic device (e.g., patient interface, computing device of an individual (patient, clinician, staff member, nurse, etc.), clinician interface, sensor internal or external to the treatment apparatus **70**, or any some combination thereof). The data may include one of a position of a body part of the patient or a force exerted by the body part. The data may include a measurement (e.g., pressure measurement from a sensor in a pedal of the treatment apparatus, speed of a motor operating within the treatment apparatus **70**, range of motion (of a limb of the patient) received from a goniometer, etc.) pertaining to performance of a treatment plan by a patient using the treatment apparatus **70**, a characteristic (e.g., a heartrate, a blood pressure, a percentage or other measurement of blood oxygen, a glucose level, a temperature, a perspiration rate, a pain level, etc.) pertaining to the patient, or both. In some embodiments, the body part is a joint, and the position of the body part comprises an angle of the joint. In some embodiments, the body part may include at least one of a joint, a bone, or a muscle group.

At **1706**, the processing device may store the data for the patient in a computer-readable medium. At **1708**, the processing device may cause a user interface to be presented on a patient interface. The user interface may include an adjustment confirmation control configured to solicit a response regarding the patient's comfort level with the one of the position of the body part or the force exerted by the body part. In some embodiments, the adjustment confirmation control may be configured to solicit the response

regarding the patient's comfort level with the force exerted by the body part. In some embodiments, the adjustment confirmation control may be configured to solicit the response regarding the patient's comfort level with the position of the body part. In some embodiments, the processing device may cause presentation of a user interface on a clinician interface, wherein the user interface comprises information regarding the one of the position of the body part or the force exerted by the body part. Causing a user interface to be presented on any computing device may include transmitting data and/or computer instructions to the computing device. The computing device may use the data and/or execute the instructions to present the user interface on a display screen. The user interface may be included in a standalone application executing on the computing device and/or in an application (website) executing within another application (web browser).

Clauses:

1. A method comprising:
   - while the a patient uses a treatment apparatus, controlling, based on a treatment plan for the patient, the treatment apparatus;
   - receiving, by a processing device, data from an electronic device, wherein the data comprises one of a position of a body part of the patient or a force exerted by the body part;
   - storing, via the processing device, the data for the patient in a computer-readable medium;
   - causing, via a processing device, presentation of a user interface on a patient interface, wherein the user interface comprises an adjustment confirmation control, and the adjustment confirmation control is configured to solicit a response regarding the patient's comfort level with the one of the position of the body part or the force exerted by the body part.

2. The method of clause 1, wherein the processing device is separate from the treatment apparatus, and the method further comprises using the processing device separate from the treatment apparatus to perform the controlling of the treatment apparatus.

3. The method of clause 1, wherein the treatment plan is a physical rehabilitation regimen for improving strength or range of motion of the body part.

4. The method of clause 1, wherein the adjustment confirmation control is configured to solicit the response regarding the patient's comfort level with the force exerted by the body part.

5. The method of clause 1, wherein the adjustment confirmation control is configured to solicit the response regarding the patient's comfort level with the position of the body part.

6. The method of clause 5, wherein the body part is a joint, and the position of the body part comprises an angle of the joint.

7. The method of clause 1, further comprising causing, via the processing device, presentation of a user interface on a clinician interface, wherein the user interface comprises information regarding the one of the position of the body part or the force exerted by the body part.

8. A computer-implemented system for physical rehabilitation, comprising:
   - a clinician interface comprising a patient profile display, wherein the patient profile display is configured to present data regarding performance, by a patient, of a regimen for a body part, the body part comprising at least one of a joint, a bone, or a muscle group;
   - a sensor configured to measure one of a position of the body part or a force exerted by the body part;
   - a patient interface including an output device and an input device configured to communicate information respectively to and from the patient regarding the performance of the regimen;
   - the patient interface configured to present instructions and status information regarding the performance of the regimen; and
   - the patient interface configured to present an adjustment confirmation control, wherein the adjustment confirmation control is configured to solicit a response regarding the patient's comfort level with the one of the position of the body part or the force exerted by the body part.

9. The computer-implemented system of clause 8, wherein the regimen is a physical rehabilitation regimen for improving strength or range of motion of the body part.

10. The computer-implemented system of clause 8, wherein the adjustment confirmation control is configured to solicit the response associated with the patient's comfort level with the force exerted by the body part.

11. The computer-implemented system of clause 8, wherein the adjustment confirmation control is configured to solicit the response associated with the patient's comfort level with the position of the body part.

12. The computer-implemented system of clause 11, wherein the body part is a joint, and the position of the body part comprises an angle of the joint.

13. The computer-implemented system of clause 8, wherein the clinician interface is configured to present information regarding the one of the position of the body part or the force exerted by the body part.

14. The computer-implemented system of clause 8, wherein the adjustment confirmation control provides an ICON configured to increase the one of the position of the body part or the force exerted by the body part during the regimen.

15. The computer-implemented system of clause 8, wherein the adjustment confirmation control provides a DCON configured to decrease the one of the position of the body part or the force exerted by the body part during the regimen.

16. The computer-implemented system of clause 8, wherein the adjustment confirmation control provides a SCON configured to maintain the one of the position of the body part or the force exerted by the body part during the regimen.

17. The computer-implemented system of clause 8, wherein the patient interface presents the adjustment confirmation control during or after the regimen.

18. The computer-implemented system of clause 8, further comprising, for performing the regimen, a treatment apparatus configured to be manipulated by the patient.

19. The computer-implemented system of clause 18, wherein the treatment apparatus comprises an actuator configured to adjust the position of the body part.

20. The computer-implemented system of clause 18, wherein the sensor is an internal sensor within the treatment apparatus.

21. A system for remote treatment, comprising:
   - a clinician interface configured to present controls for modifying a treatment plan comprising a regimen for treatment of a body part of a patient, with the body part comprising at least one of a joint, a bone, or a muscle group;

a treatment apparatus for performing the regimen upon the body part, the treatment apparatus configured to be manipulated by the patient;

a patient interface including an output device and an input device for communicating information respectively to and from the patient regarding the performance of the regimen;

wherein the patient interface and the treatment apparatus are each configured to enable operation from a patient location geographically separate from a location of the clinician interface; and

the patient interface configured to present an adjustment confirmation control, wherein the adjustment confirmation control is configured to solicit a response regarding the patient's comfort level with one of a position of the body part or a force exerted by the body part.

22. The system of clause 21, wherein the treatment plan comprises a target setting for the one of the position of the body part or the force exerted by the body part.

23. The system of clause 21, wherein the regimen is a physical rehabilitation regimen for improving strength or range of motion of the body part.

24. The system of clause 21, wherein the adjustment confirmation control is configured to solicit the response regarding the patient's comfort level with the position of the body part.

25. The system of clause 24, wherein the body part is a joint, and the position of the body part comprises an angle of the joint.

26. A patient user interface generated by a computer and comprising:

a session period action screen configured to present real-time status of a measurement regarding a patient's use of a treatment apparatus for performing a regimen for a body part, the body part comprising at least one of a joint, a bone, or a muscle group;

an adjustment confirmation control configured to solicit a response regarding the patient's comfort level with one of a position of the body part or a force exerted by the body part; and

wherein the measurement regarding the patient's use of the treatment apparatus includes the one of the position of the body part or the force exerted by the body part.

27. The patient user interface of clause 26, wherein the adjustment confirmation control provides an ICON configured to increase the one of the position of the body part or the force exerted by the body part during the regimen; and

wherein the adjustment confirmation control provides a DCON configured to decrease the one of the position of the body part or the force exerted by the body part during the regimen.

28. The patient user interface of clause 26, wherein the adjustment confirmation control provides a SCON configured to maintain the one of the position of the body part or the force exerted by the body part during the regimen.

As will readily be appreciated by a person of ordinary skill of the art in light of having read the present disclosure, as used herein, actions described as being performed in real-time include actions performed in near-real-time without departing from the scope and intent of the present disclosure.

The various aspects, embodiments, implementations, or features of the described embodiments can be used separately or in any combination. The embodiments disclosed herein are modular in nature and can be used in conjunction with or coupled to other embodiments.

Consistent with the above disclosure, the examples of assemblies enumerated in the following clauses are specifically contemplated and are intended as a non-limiting set of examples.

What is claimed is:

1. A method comprising:

controlling, by a processing device, while a patient uses a treatment apparatus, the treatment apparatus, based on a treatment plan for the patient, the treatment plan comprising a target force setting value to be exerted by a body part of the patient, the treatment apparatus comprising an actuator configured to produce an external force based on the target force setting value;

causing, via the processing device, presentation of a first user interface on a patient interface, wherein the first user interface comprises an adjustment confirmation screen that solicits a response regarding the patient's comfort level with the target force setting value;

changing, based on the response, the target force setting value; and

controlling the actuator to produce an external force based on the changed target force setting value.

2. The method of claim **1**, wherein the processing device is separate from the treatment apparatus.

3. The method of claim **1**, wherein the treatment plan is a physical rehabilitation regimen for improving strength.

4. The method of claim **1**, further comprising causing, via the processing device, presentation of a second user interface on a clinician interface, wherein the second user interface comprises information regarding a force exerted by the body part of the patient.

5. The method of claim **1**, wherein the adjustment confirmation screen comprises a decrease control configured to decrease the target force setting value.

6. The method of claim **1**, wherein the adjustment confirmation screen comprises a stay control configured to maintain the target force setting value.

7. The method of claim **1**, wherein the actuator is further configured to adjust a position of the body part of the patient.

8. A computer-implemented system for physical rehabilitation, comprising:

a clinician interface comprising a patient profile display, wherein the patient profile display is configured to present data regarding performance, by a patient using a treatment apparatus, of a regimen for a body part, wherein the regimen comprising a setting value of a target force to be exerted by the body part, the body part comprising at least one of a joint, a bone, or a muscle group, and the treatment apparatus comprising an actuator configured to produce an external force based on the setting value of the target force; and

a patient interface configured to present an adjustment confirmation control screen, wherein the adjustment confirmation screen is configured to solicit a response regarding the patient's comfort level with the setting value of the target force,

wherein, based on the response regarding the patient's comfort level with the setting value of the target force, the setting value of the target force is changed and the actuator is controlled to produce an external force based on the changed setting value of the target force.

9. The computer-implemented system of claim **8**, wherein the regimen is a physical rehabilitation regimen for improving strength.

10. The computer-implemented system of claim 8, wherein the clinician interface is further configured to present information regarding a force exerted by the body part of the patient.

11. The computer-implemented system of claim 8, wherein the adjustment confirmation screen comprises an increase control configured to increase the setting value of the target force.

12. The computer-implemented system of claim 8, wherein the adjustment confirmation screen comprises a decrease control configured to decrease the setting value of the target force.

13. The computer-implemented system of claim 8, wherein the adjustment confirmation screen comprises a stay control configured to maintain the setting value of the target force.

14. The computer-implemented system of claim 8, wherein the actuator is further configured to adjust a position of the body part of the patient.

15. A system for remote treatment, comprising:

a clinician interface configured to present controls for modifying a treatment plan comprising a regimen for treatment of a body part of a patient, with the body part comprising at least one of a joint, a bone, or a muscle group, and the regimen comprising a setting value of a target force to be exerted by the body part; and

a patient interface and a treatment apparatus each configured to enable operation from a patient location geographically separate from a location of the clinician interface,

wherein the patient interface is configured to present an adjustment confirmation control screen, the adjustment confirmation control screen configured to solicit a response regarding the patient's comfort level with the setting value of the target force, and

wherein, based on the response, the setting value of the target force is changed and an actuator of the treatment apparatus is controlled to produce an external force according to the changed setting value of the target force.

16. The system of claim 15, wherein the regimen is a physical rehabilitation regimen for improving strength.

17. The system of claim 15, wherein the clinician interface is further configured to present information regarding the force exerted by the body part of the patient.

18. The system of claim 15, wherein the adjustment confirmation screen comprises an increase control configured to increase the setting value of the target force.

19. The system of claim 15, wherein the adjustment confirmation screen comprises a decrease control configured to decrease the setting value of the target force.

20. The system of claim 15, wherein the adjustment confirmation screen comprises a stay control configured to maintain the setting value of the target force.

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