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Effectiveness of adaptive utensils on hand and finger range of motion in individuals with rheumatoid arthritis

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Abstract

Individuals with Rheumatoid Arthritis (RA) often experience functional deficits that impair range of motion (ROM) in their hands and fingers. Daily tasks like opening jars and eating become more difficult and painful for individuals with RA because they lack the grip strength and adequate ROM to perform these activities. Because of this, efforts have been made to accommodate decreasing functionality due to decreased ROM. Adaptive utensils are currently being explored as a potential aid for hand and finger functional deficits. This study sought to quantify the ROM needed for individuals with RA to grip the handles of adaptive utensils of varying diameters to better understand the advantages that such devices might have for this population. Thirty-eight individuals representing seventy-six hands were recruited for this study. The ROM of the metacarpophalangeal (MCP) joint, proximal interphalangeal (PIP) joint, and distal interphalangeal (DIP) joint was measured using an electrogoniometer for fingers 2-5. The MCP and interphalangeal (IP) joints were measured for the thumb. The measurements were repeated using three spoons: standard handle, built-up 1-inch (2.54 cm) handle, and built-up 1.5-inch (3.81 cm) handle. A repeated measures ANOVA yielded significant differences for all joints between the three handle conditions except for the 1st MCP joint, which found a significant difference between the dominant and non-dominant sides. It was found that as spoon handle diameter increased, the ROM required for individuals to grip the spoons decreased. These findings could potentially benefit those with RA and other impairments who might be aided through the use of adaptive and built-up utensils.

Introduction

Rheumatoid Arthritis (RA) is an autoimmune disease that affects the joints in one's body by causing the tissue surrounding the joints to thicken, thereby causing pain (Arthritis Foundation, 2018). RA can affect any joint but is primarily found in the joints of the hands, wrists, and knees (Arthritis Foundation, 2018). People with RA can experience extreme pain, instability, and deformity of joints (Arthritis Foundation, 2018). (Appendix A). Within the United States, approximately 1.5 million people are afflicted with RA (Arthritis Foundation, 2018). Furthermore, RA disproportionally affects women more than men, with the rate of RA amongst women two to three times higher than the rate amongst men (CDC, 2017). The primary age of onset for individuals with RA is in their sixties, but RA can develop at any time (CDC, 2017).

Individuals with RA experience many limitations due to the disease. Per Griffith and Carr (2001), these limitations can extend from their day to day activities to work to leisure activities. A primary concern of people with RA is their loss of independence (Lutze & Archenholtz, 2007). Because of these limitations, it is important to determine ways in which to reduce pain and help individuals suffering from RA to maintain some of that independence. One way to do this is by assisting people in overcoming deficits in their range of motion (ROM). For people with RA, daily tasks become harder because the disease often reduces the ROM of the joints that it affects. Tasks that used to be performed without a second thought can often be painful and require much more effort.

This study will primarily be focusing on the ROM in the hands and fingers of individuals with RA when utilizing adaptive utensils. Specifically, it will seek to quantify the ROM needed for a person with RA to grasp spoons with built-up handles of various diameters. A previous study conducted by McDonald, Levine, Richards, and Aguilar (2016) showed that the ROM required to grasp the spoons in persons with normal hand function decreased with increasing spoon diameter. However, this study will attempt to bridge the gap by providing evidence that the ROM required to grip built-up spoon handles in individuals with RA decreases with increasing spoon diameter. By quantifying this data and providing the evidence showing that people with RA can use less ROM when utilizing adaptive utensils, more studies regarding its benefit will hopefully be done, prompting a small solution to the pain and loss of independence facing individuals with RA.

In order to understand the significance of this study and the potential role of adaptive utensils in the life of a person with RA, it is important to explore the research surrounding this topic and related areas of study. First, the implications of arthritis as a major disease must be addressed. A further exploration of the role of ROM on an individual's ability to carry out activities of daily living (ADL) should similarly be undertaken. Lastly, research conducted on the use of adaptive devices in persons with arthritis must be explored. Compiling this information will help provide the basis for this study and hopefully show the need for more research in this area.

Arthritis is a widespread disease affecting millions of people of all ages. As of 2015, the CDC (2018) estimates that over 54 million U.S. adults are afflicted with some form of arthritis. This includes only those who have been diagnosed by a doctor, not including those that may currently have the disease but have not been seen by a qualified clinician (CDC, 2018). Per Lawrence et al. (1998), this number is expected to grow to approximately 59.4 million individuals by the year 2020. By 2040, the CDC (2018) estimates that around 78 million U.S. adults will be diagnosed with the disease. Out of these numbers, approximately 1.5 million of these individuals currently have RA (Arthritis Foundation, 2018). Looking at current trends, that number will only be expected to increase. With so many people currently affected, and the significant number of people proposed to be affected by arthritis, solutions must be reviewed to help alleviate some of the adverse conditions arising from this disease.

One such adverse condition that results from arthritis is reduced ROM in the joints of individuals with the disease. A study done by Bland, Beebe, Hardwick, and Lang (2008) simulated diseases in which ROM is reduced, including arthritis and stroke. To conduct their study, they restricted the shoulder, wrist, fingers, elbow, and forearm of both younger and older participants. They then had the participants complete the Jebsen-Taylor Test of Hand Function (Bland, Beebe, Hardwick, & Lang, 2008). The study found that restricting the ROM at each location, minus the shoulder, significantly decreased the hand function of the individuals (Bland, Beebe, Hardwick, & Lang, 2008). It is important to note that the restrictions of each segment occurred individually, not all at once (Bland, Beebe, Hardwick, & Lang, 2008).

More studies have shown the effect of reduced ROM on hand function. A study done by Bazanski (2010) addresses the ROM of the metacarpophalangeal (MCP) joints of the fingers. Through his research with the three-dimensional motion analysis system, Bazanski (2010) determines the importance of a fully functional MCP joint in allowing individuals adequate grip function for certain types of grips. He acknowledges that RA limits this functional ability, which is paramount for individuals to be able to grip objects effectively (Bazanski, 2010). Both aforementioned studies indicate that with decreasing ROM comes less hand and finger functionality, which yields less independence for individuals suffering from RA as their hand functions diminish with disease progression.

With these issues in mind, attempts have been made to accommodate decreasing functionality due to reduced ROM. Adaptive devices have long been a staple for people with reduced functionality. They are provided to help people with functional deficits maintain their independence for as long as possible. While certain devices are more commonplace than others, the role of adaptive utensils has been less explored. As previously mentioned, the study performed by McDonald, Levine, Richards, and Aguilar (2016) showed that ROM of individuals with normal hand function decreased with increasing spoon handle diameter. However, not much is known about the potential benefits of adaptive utensils for people with RA. This is the primary area of study for which this research attempts to address.

Methods

Participants

Thirty-eight individuals representing seventy-six hands between the ages of 33-79 were recruited for this study from University Rheumatology Associates at Erlanger Hospital. Every Friday, researchers were allowed access to a room in the rheumatology department and physicians would send their patients to the researchers' room for potential inclusion in the study. Inclusion criteria were; diagnosed with RA, 18 years or older, and no comorbidities that could further impair ROM of the hands and fingers. Those that did not meet these requirements were excluded from the study (Appendix B). Individuals were provided with an informed consent document to sign prior to inclusion in the study, previously approved by the Institutional Review Board (IRB) at the University of Tennessee at Chattanooga (IRB #17-117). At the conclusion of the study, participants were given an adapted spoon for their participation.

Procedure

Prior to any measurements being taken, participants were briefed on the purpose of the study and the testing procedure. Participants were then asked preliminary questions relating to demographics and history of RA. Grip strength and ROM in the joints of the fingers were assessed. Grip strength was calculated using the Jamar hydraulic hand dynamometer (Patterson Medical, Warrenville, IL, USA). To obtain this measurement, participants were asked to hold their arm by their side with the elbow flexed to 90 degrees. They were then asked to squeeze the dynamometer as hard as they were physically able to. This was performed three times on each side and the average taken.

ROM in the joints of the fingers was calculated using the Biometrics F35 Single Axis Electrogoniometer (Biometrics Ltd, Ladysmith, VA, USA). Participants placed their forearm on a foam arm rest elevated at a comfortable angle. They were then asked to grip spoons of increasing diameters one at a time, beginning with a standard handle spoon, built-up handle of 1.00 inches (2.54 cm), and built-up handle of 1.50 inches (3.81 cm). (Appendix C)

Measurements of the metacarpophalangeal (MCP), proximal interphalangeal (PIP), and distal interphalangeal (DIP) joints were taken for fingers 2-5 (index, middle, ring, and pinky fingers). The joints measured for finger 1 (thumb) were the MCP and interphalangeal (IP) joints. Measurements were gathered for one hand, and then the same procedure was performed for the opposite hand. Following each participant, the electrogoniometer was recalibrated to ensure accuracy of measurements (Appendix D).

Analysis

The means and standard deviations of all ROM measures were compared using repeated measures ANOVAs relating the spoons, fingers, and joints to determine how ROM differed based on these variables. Post-hoc analyses were then performed to determine the differences within each factor. The alpha level used to designate significance in this study was $p<0.05$.

Results

A repeated measures ANOVA (dominant/non-dominant, spoon handle diameter) was performed for each joint and finger. Main effects (Table 1) showed significant differences in ROM between handle conditions for all joints with the exception of the 1st MCP which showed differences between the dominant and non-dominant sides $F_{(1,36)}=6.2$, $p<0.017$, $\eta_p^2=0.144$. For the handle conditions the significant differences included: 1st IP $F_{(2,36)}=10.2$, $p<0.001$, $\eta_p^2=0.217$; 2nd MCP $F_{(2,36)}=19.0$, $p<0.001$, $\eta_p^2=0.339$; 2nd PIP $F_{(2,36)}=54.4$, $p<0.001$, $\eta_p^2= 0.595$; 2nd DIP $F_{(2,36)}=43.8$, $p<0.001$, $\eta_p^2= 0.543$; 3rd MCP $F_{(2,36)}$ $=11.6$, $p<0.001$, $\eta_p^2= 0.239$; 3rd PIP $F_{(2,36)}=154.2$, $p<0.001$, $\eta_p^2= 0.807$; 3rd DIP $F_{(2,36)}=78.2$, $p<0.001$, $\eta_p^2= 0.679$; 4th MCP $F_{(2,36)}=6.1$, $p<0.003$, $\eta_p^2=0.142$; 4th PIP $F_{(2,36)}=277.3$, $p<0.001$, $\eta_p^2=0.882$; 4th DIP $F_{(2,36)}=67.9$, $p<0.001$, $\eta_p^2=0.647$; 5th MCP $F_{(2,36)}=5.9$, $p<0.004$, $\eta_p^2=0.138$; 5th PIP $F_{(2,36)}= 522.5$, $p<0.001$, $\eta_p^2=0.934$; and 5th DIP $F_{(2,36)}=121.5$, $p<0.001$, $\eta_p^2=0.767$. Pairwise comparisons showed significant differences between all handle conditions except for between the standard and 1-inch grips for the 3rd, 4th and 5th finger MCP joints (Tables 2-6).

Table 1. Descriptive statistics and main effects from repeated measures ANOVA.

	Dominant Mean (sd)			Non-dominant Mean (sd)		
	Standard	1-inch	1.5-inch	Standard	1-inch	1.5-inch
1st MCP †	28.5 (17.6)	31.2 (21.7)	32.2 (19.6)	25.3 (19.6)	26.2 (19.1)	27.1 (21.7)
1st IP *	11.3 (27.2)	17.8 (24.6)	23.6 (20.3)	5.8 (31.9)	21.8 (20.6)	20.8 (19.2)
2nd MCP *	75.3 (11.0)	67.4 (11.9)	62.6 (12.5)	72.3 (15.1)	71.1 (15.1)	65.6 (15.2)
2nd PIP *	89.9 (22.7)	75.2 (10.5)	67.6 (8.0)	90.9 (21.6)	75.0 (9.6)	68.3 (7.6)
2nd DIP *	48.3 (11.6)	44.7 (11.5)	39.7 (10.8)	55.6 (13.0)	45.4 (10.6)	39.6 (9.8)
3rd MCP *	81.1 (13.1)	77.5 (11.5)	73.2 (11.4)	76.8 (15.5)	77.0 (12.0)	74.8 (12.7)
3rd PIP *	93.9 (17.0)	76.0 (9.2)	66.5 (8.8)	97.9 (9.1)	76.1 (13.4)	66.9 (7.5)
3rd DIP *	56.7 (13.7)	45.6 (13.1)	41.6 (10.8)	60.6 (10.8)	48.4 (10.7)	41.3 (9.3)
4th MCP *	77.1 (10.4)	72.1 (11.4)	69.4 (13.2)	71.1 (15.3)	72.2 (14.4)	69.5 (12.8)
4th PIP *	97.4 (17.1)	73.5 (9.9)	65.1 (9.7)	98.8 (9.9)	75.4 (8.6)	63.9 (8.7)
4th DIP *	51.0 (14.4)	41.3 (9.9)	35.2 (9.4)	55.4 (12.7)	44.0 (11.7)	34.9 (9.6)
5th MCP *	81.3 (12.8)	77.1 (15.2)	72.7 (14.9)	75.6 (19.7)	75.1 (16.4)	72.6 (15.0)
5th PIP *	86.3 (15.7)	58.0 (10.5)	46.0 (10.1)	90.8 (10.1)	57.3 (11.4)	48.0 (10.4)
5th DIP *	57.3 (17.0)	42.3 (13.9)	36.6 (14.5)	60.4 (14.7)	43.3 (15.1)	34.3 (14.9)

Note. * significant differences between handle conditions p<0.05
† significant differences between sides

Table 2. Comparison of thumb (first finger) ROM using a standard spoon, and two commercial spoons with enlarged diameter handles (1-inch and 1.5-inch).

Handle Size	MCP	IP*
Standard Handle	26.90° ± 19.60°	8.55° ± 31.90°
1-inch handle	28.70° ± 21.70°	19.8° ± 24.60°
1.5-inch handle	29.65° ± 21.70°	22.20° ± 20.30°

Note. *Difference between standard handle and 1-inch handle (P < 0.01)
**Difference between 1 inch and 1.5-inch handles (P < 0.01)
†Difference between standard and 1.5-inch handles (P < 0.01)

Table 3. Comparison of index finger (second finger) ROM using a standard spoon, and two commercial spoons with enlarged diameter handles (1-inch and 1.5-inch).

Handle Size	MCP*	PIP*	DIP*
Standard handle	73.80° ± 15.10°	90.40° ± 22.70°	51.95° ± 13.00°
1-inch handle	69.25° ± 15.10°[*]	75.10° ± 10.50°[*]	45.05° ± 11.50°[*]
1.5-inch handle	64.10° ± 15.20°[**,†]	67.95° ± 8.00°[**,†]	39.30° ± 10.80°[**,†]
Note. *Difference between standard handle and 1-inch handle (P < 0.01) **Difference between 1-inch and 1.5-inch handles (P < 0.01) †Difference between standard and 1.5-inch handles (P < 0.01)			

Table 4. Comparison of middle finger (third finger) ROM using a standard spoon, and two commercial spoons with enlarged diameter handles (1-inch and 1.5-inch).

Handle Size	MCP*	PIP*	DIP*
Standard handle	78.95° ± 15.50°	95.90° ± 17.00°	58.65° ± 13.70°
1-inch handle	77.25° ± 12.00°	76.05° ± 13.40°[*]	47.00° ± 13.10°[*]
1.5-inch handle	74.00° ± 12.70°[**,†]	66.70° ± 8.80°[**,†]	41.45° ± 10.80°[**,†]
Note. *Difference between standard handle and 1-inch handle (P < 0.01) **Difference between 1-inch and 1.5-inch handles (P < 0.01) †Difference between standard and 1.5-inch handles (P < 0.01)			

Table 5. Comparison of ring finger (fourth finger) ROM using a standard spoon, and two commercial spoons with enlarged diameter handles (1-inch and 1.5-inch)

Handle Size	MCP*	PIP*	DIP*
Standard handle	74.10° ± 15.30°	98.10° ± 17.10°	53.20° ± 14.40°
1-inch handle	72.15° ± 14.40°	74.45° ± 9.90°[*]	42.65° ± 11.70°[*]
1.5-inch handle	69.45° ± 13.20°[**,†]	64.50° ± 9.70°[**,†]	35.05° ± 9.60°[**,†]
Note. *Difference between standard handle and 1-inch handle (P < 0.01) **Difference between 1-inch and 1.5-inch handles (P < 0.01) †Difference between standard and 1.5-inch handles (P < 0.01)			

Table 6. Comparison of pinky finger (fifth finger) ROM using a standard spoon, and two commercial spoons with enlarged diameter handles (1-inch and 1.5-inch).

Handle Size	MCP*	PIP*	DIP*
Standard handle	78.45° ± 19.70°	88.55° ± 15.70°	58.85° ± 17.00°
1-inch handle	76.10° ± 16.04°	57.65° ± 11.40°*	42.80° ± 15.10°*
1.5-inch handle	72.65° ± 15.00°**,†	47.00° ± 10.40°**,†	35.45° ± 14.90°**,†
Note. *Difference between standard handle and 1-inch handle ($P < 0.01$) **Difference between 1-inch and 1.5-inch handles ($P < 0.01$) †Difference between standard and 1.5-inch handles ($P < 0.01$)			

Discussion

Interpretation

The aim of this study was to quantify the ROM required for individuals with RA in their hands and fingers to grasp built-up utensils. It was hypothesized that as spoon handle diameter increased, the ROM required to grip the spoons would decrease. The data collected for this study supports this hypothesis. In all finger joints except for the 1st MCP, there was a significant difference between the three handle conditions. Further analysis confirmed that there were significant differences in all the joints between the various handle conditions except for between the standard and 1-inch handles for the 3rd, 4th, and 5th MCP joints. The data indicates that the PIP joint experienced the greatest change in ROM between handle conditions, followed by the DIP joint. While all the joints are involved in the grasping of the spoons, the PIP and DIP joints undergo the greatest amount of change. These findings provide support for the idea that adaptive and built-up utensils could be used by individuals with functional deficits and reduced ROM in their hands and fingers to overcome these impairments.

Limitations

While most of the joints showed a decreasing ROM required to grip a built-up handle, the thumb showed an increasing ROM required for grasping the greater diameter spoons. This could be attributed to the way the individuals held the spoons. Individuals were told to hold the spoons in a gross grip rather than a functional grip, as one would use to eat. This resulted in variations of thumb position depending on the individual. Future studies could investigate this discrepancy by studying the ROM in the thumb when individuals grasp utensils in a functional grip. Another limiting factor for this study was that all individuals were recruited from the same hospital. This limited the number of different individuals seen over the data collection period. More partnerships with other area hospitals could improve this limitation.

Future Studies

There is presently not much research on the use of adaptive utensils for individuals with various functional impairments. However, this is a field of study that deserves attention for the potential benefits that adaptive utensils might provide. Although this research focused on individuals with RA, several other diagnoses were encountered, including Dupuytren’s Contracture and Psoriatic Arthritis. This indicates a great need for adaptive utensils, as the functional deficits were not limited to those with RA. Through this study, it is hoped that quantifying the ROM required for individuals with RA to grasp built-up utensils will promote more research to develop optimal adaptive utensils and determine the improvements that these devices might provide for individuals who suffer from various problems that affect their ability to carry out activities of daily living.

Other potential research opportunities stemming from this study include determining the role of grip strength in an individual’s ability to grasp adaptive utensils, as well as seeing if there is an association between the number of years that a person has RA and their ROM capabilities. Although the data for grip strength and number of years with RA was collected, it was not used in this study, so further analyses would need to be performed to establish this relationship.

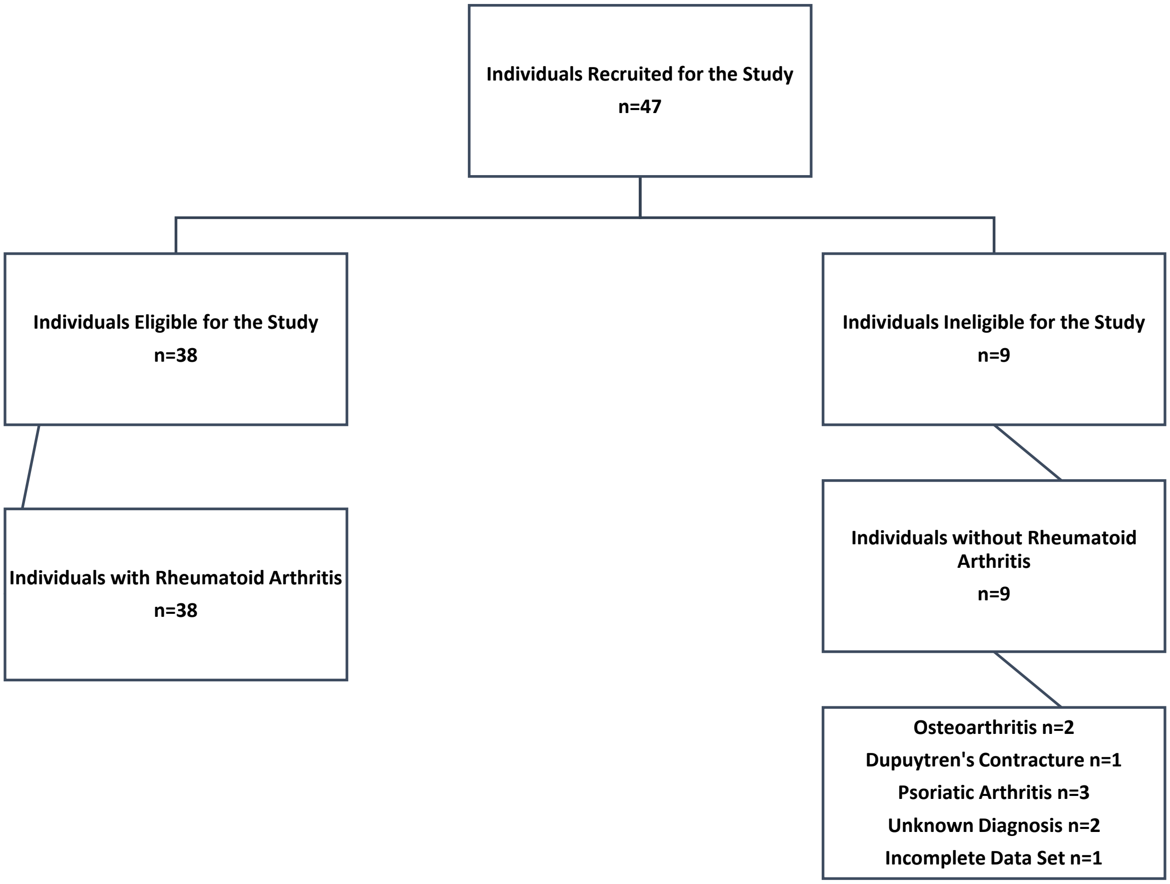
Appendix A

Individual with RA

This picture depicts an individual from the study with an RA diagnosis. The picture highlights the impairments of the joints, specifically the third PIP and DIP, and the fourth PIP.

Appendix B

Participant Flow Diagram



This participant flow diagram shows how many individuals were recruited for the study, how many were able to be included, and how many had to be excluded as well as the reason for their exclusion from participation.

Appendix C

Built-up Spoons

The above spoons were used in the study. From left to right: standard spoon, built-up 1-inch diameter spoon, built-up 1.5-inch diameter spoon.

Appendix D

Visual of Procedure

This picture shows the procedure used for data collection in this study. The researcher is taking measurements using an electrogoniometer of the second MCP with the participant holding the built-up 1.5-inch diameter spoon.

Appendix E

Demographics

Subject	Hand Dominance (R=1, L=2)	Age (years)	Weight (pounds)	Gender (M=1, F=2)	Years with RA
1	1	62	-	2	15
2	1	66	223	1	29
3	1	66	172	2	40
4	1	68	200	2	7
5	1	51	187	2	11
6	1	63	173	2	2
7	1	57	170	2	8
8	2	46	214	1	6
9	1	74	-	1	1
10	1	63	187	1	30
11	1	66	189	2	14
12	1	44	210	1	24
13	1	69	153	2	29
14	1	78	240	1	-
15	1	71	99	2	21
16	1	49	271	1	21
17	1	69	209	1	27
18	1	70	190	2	30
19	2	59	240	2	11
20	1	50	200	2	1
21	1	79	133	2	39
22	1	49	301	2	8
23	1	56	150	1	15
24	1	54	211	2	-
25	1	70	133	2	10

Subject	**Hand Dominance (R=1, L=2)**	**Age (years)**	**Weight (pounds)**	**Gender (M=1, F=2)**	**Years with RA**
26	2	38	148	1	1
27	1	51	199	2	0.5
28	1	72	161	2	-
29	1	60	180	1	0.04
30	2	48	200	2	10
31	1	66	122	2	20
32	1	33	180	1	18
33	1	63	120	1	15
34	2	68	288	2	24
35	1	52	110	2	5
36	1	68	259	2	-
37	1	61	212	2	8
38	1	56	180	2	-

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