Specific and Non-specific Factors of Animal-Assisted Interventions Considered in Research: A Systematic Review

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Research on animal-assisted interventions (AAIs) has increased massively in the last few years. But it is still not clear how AAIs work and how important the animal is in such interventions. The aim of this systematic review was to compile the existing state of knowledge about the working mechanisms of AAIs. We searched 12 major electronic databases for previous AAI studies with active control groups. Of 2001 records identified, we included 172 studies in the systematic review. We extracted previously published hypotheses about working mechanisms and factors that have been implicitly considered specific or non-specific in AAI research by categorizing control conditions using content analysis. We analyzed the categories using descriptive statistics. We found that 84% of the included studies mentioned a hypothesis of working mechanisms, but 16% did not define specific hypotheses. By analyzing their control conditions, we found that in most controlled studies, the animal or the interaction with the animal was implicitly considered as a specific factor for the effects of the AAI. Non-specific factors such as therapeutic aspects, social interactions, or novelty have also been controlled for.

We conclude that AAI research still cannot answer the question of how and why AAIs work. To address this important research gap, we suggest using component studies with innovative control conditions and results from placebo research to address both the specific and non-specific, contextual factors of AAIs to disentangle its mechanisms.

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INTRODUCTION

Research on animal-assisted interventions (AAIs) has increased massively in the last few years (Rodriguez et al., 2021). But it is still not clear how important the animal is in such interventions. In 2012, Marino addressed construct validity in AAIs and concluded in a review that it is a hugely neglected topic (Marino, 2012). One decade later, the evidence of the effectiveness of AAIs is
increasing (Waite et al., 2018; Wood and Fields, 2019; Borgi et al., 2020; Babka et al., 2021; Chang et al., 2021; Diniz Pinto et al., 2021; Hediger et al., 2021; Niefroth et al., 2021), but the question of construct validity is still unresolved. Previous research has mainly focused on investigating if AAIs work but almost entirely ignored the question of how it works. The claim that the underlying mechanisms of AAIs are not clear is not new, but it is intensifying, and researchers are debating the internal validity of a broad range of different interventions that are all subsumed under the umbrella term of AAI (Kazdin, 2017; Serpell et al., 2017; López-Cepero, 2020; Rodriguez et al., 2021).

AAIs are based on the assumption that the animal is the key relevant component for the effects of such interventions. It has been proposed that an animal adds something different to a therapeutic setting compared to a human or another stimulus. The literature has therefore claimed that a live animal is a highly specific component of AAIs (Marino, 2012). It is, however, still unclear if the living animal itself—and if so, what specific characteristics of the animal—leads to the documented effects of AAIs. Specificity is a major challenge in current AAI research, so it is crucial to identify if the effects of AAIs are due to the presence of an animal specifically.

López-Cepero (2020) proposed a component-centered approach to investigate how AAIs work. AAIs consist of a complex mixture of components such as being confronted with a novel stimulus and situation, receiving increased attention from a therapist, engaging in increased physical activity and physical contact, or sometimes even being in a different environment. AAI should thus be seen as a treatment (such as psychotherapy, speech therapy, or physiotherapy) or even as a specific manualized therapy (such as cognitive behavioral therapy, for example) with the addition of a specific component: the animal. We agree with this approach of disentangling the effect of different treatment components, but we propose going even a step further by using a component-centered approach to look at the animal, the added component. The animal itself is a complex stimulus with different characteristics (Marino, 2012; Rodriguez et al., 2021): for example, animals react to clients’ behavior, move proactively, have fur or feathers, come in different shapes and colors, and have varying temperaments and personalities. All of these characteristics could lead to different effects.

Component studies are the best method for examining the active components of a treatment (Cuijpers et al., 2019). Their study designs can decompose multicomponent treatments by comparing the complete intervention with an intervention in which one component is left out (dismantling studies) or with an intervention with an additional component (additive studies) (Bell et al., 2013; Mira et al., 2019). The effects of an intervention can be distinguished into specific effects and contextual, or non-specific, effects (Wampold, 2021). Specific effects are effects that are caused by the specific intervention, while contextual, or non-specific, effects result from factors that are not specific to the intended intervention and that appear in every intervention, such as treatment expectations, the therapeutic alliance (Rossettini et al., 2018; Wampold, 2021), novelty, demand characteristics, and effects from experimenters’ expectations (Marino, 2012). Such non-specific effects are considered as confounding variables that can affect internal and external validity (Carlino et al., 2011; Geers and Miller, 2014).

It is crucial that we begin to understand what makes AAIs effective. To pursue this goal, we must know what mechanisms, specific factors, and non-specific factors have been investigated so far. While older studies usually did not control for non-specific effects, recent studies have started to dismantle the potential components of AAIs and even of the animal by using more specific and rigorous controls. Investigating the used control conditions in previous AAI studies makes it possible to infer the authors’ assumptions about the specific and non-specific effects of AAIs.

The aim of this systematic review was to compile the existing state of knowledge about how AAIs work. To do so, we collected the explicitly stated hypotheses about the working mechanisms of AAIs mentioned in previous studies and compared the control condition with the experimental condition of previous AAI studies in order to derive which implicit specific and non-specific factors of AAI have been considered to be relevant so far.

METHODS

Search Strategy
We conducted a systematic literature search in the following databases: PsychINFO, PSYNDEx, ERIC, MEDLINE, Embase, PubMed, Cochrane Library, Web of Science, Scopus, CINAHL, PTDSPubs, and Dissertations and Theses. A summary of the applied search strategies can be found in Appendix Table S1. We also used other sources to identify studies.

We imported all the records into Covidence, a systematic review software (Veritas Health Innovation, Melbourne, Australia), where duplicates were identified and removed. The screening was also performed in Covidence. The titles and abstracts of the included records were screened by two independent researchers in duplicate to exclude obvious irrelevant references and duplicates. Full texts were again screened by two independent researchers in duplicate to examine the records in more detail for inclusion and exclusion criteria. Conflicts were resolved by consensus among all the researchers involved in the screening process (CW, KH, and CG).

Identifying, screening, and determining the eligibility of the studies was done according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2018). The study procedure was defined a priori, and the protocol was preregistered with PROSPERO (registration number: CRD42020158103). The date of the last search was January 13, 2022.

Study Selection
We used the PICO elements Intervention and Comparison to include relevant studies (EUnetHTA, 2019; Frandsen et al., 2020). The elements Population and Outcomes were irrelevant for this review (all were included). To be eligible for inclusion, studies had to (1) investigate an AAI (Intervention), (2) include an active control group (Comparison), and (3) be written in English or German.
We included all studies that examined a type of AAI (e.g., animal-assisted therapy, animal-assisted activity, animal-assisted education, hippotherapy, pet therapy) with a live animal (Intervention). We followed the terminologies of the IAHAIO (2018) and included every study with an intervention that can be considered an AAI according to the IAHAIO definition. We excluded studies on pet ownership. We included all type of study design as long there was an active control group (i.e., randomized controlled trial, cross-over study) (Comparison). We included all forms of active control conditions. Active control was defined as a condition in which the participants received a specific intervention offered by the study team. We excluded studies where participants in the control condition received standard care (i.e., care that was not offered by the study team), where they were on a waiting list, or where the study was a pre–post design with only one group. Further, we excluded studies that were only registered as clinical trials and abstracts or poster presentations, because they did not provide sufficient information for our review. We contacted the study authors if a record was not available through university libraries. Studies were excluded if we were not able to receive the full text (see Figure 1 for the flow chart).

We first screened the titles and abstracts of the records. During full-text screening we excluded all records that did not fulfill all our inclusion criteria.

Data Extraction
Prior to the data extraction, all researchers received training in using the form for extracting information on the following categories: first author's name and country, publication year, the characteristics of the experimental and control intervention, factor hypotheses, and the animal included in the study.

In a first step, all the data were independently extracted and coded in duplicate by a team of five research assistants in Microsoft Office Excel 2016. In a second step, all disagreements between the two raters were identified independently by two researchers, and conflicts were resolved by consensus among all the researchers involved in the screening process (CW, KH, and CG).

Data Analyses
To extract the factor hypotheses, the specific factors, and the non-specific factors, we used structured qualitative content analysis following Mayring (2014). Two independent raters analyzed the manuscripts independently in a first step and extracted the hypotheses, the specific factors, and the non-specific factors. The content was reduced to units of meaning that were then consolidated to items. In a second step, the two coding schemes were compared, disagreements were discussed with two authors (CW and KH), and consensus was reached on one scheme. One author (CG) defined superordinate categories for the items of the extracted hypotheses, the specific and non-specific factors. These proposed superordinate categories were then discussed with the other two authors (CW and KH) and adjusted. All hypotheses and factors that were not mentioned more than twice and did not fit into any existing category were classified as “other.”

We analyzed the categories using descriptive statistics. The base rate for the study characteristics, factor hypotheses, and specific and non-specific factors was the total number of the included studies (N = 172). Descriptive analyses were carried out using R for Mac, version 1.4.1103.

Factor Hypotheses
We defined factor hypotheses as hypotheses, factors, or mechanisms that authors mentioned in the introductions of their studies to explain how AAIs work. It was possible for a study to mention several hypotheses. Two independent raters independently extracted factor hypotheses in the studies. All disagreements were solved by two authors (CW and KH). After that, two authors (CW and KH) reviewed the categories of the factor hypotheses and subsumed them into 11 main categories.

Specific Factors of AAIs
We defined a factor as specific if it was present in the experimental condition but not in the control condition. Two raters independently compared the characteristics of the experimental interventions and the control interventions. All factors that were not present in the control conditions were coded as specific factors. The two raters extracted the factors independently. After that, they independently summarized the factors into categories. All disagreements were resolved by a third rater (CW). Then two researchers (CW and KH) reviewed the categories and subsumed them into nine main categories.

Items were listed in several categories if they were applicable. For example, the item training in animal care was included in category 5, “taking care of an animal,” because aspects of taking care of an animal were present and in category 8, “education about an animal,” because subjects received training (see Table 2; Figures 3, 4).

Non-specific Factors of AAIs
All factors that existed in both the experimental and the control interventions were defined as non-specific factors. Two independent raters compared the experimental and control conditions from each study and independently listed all the factors that occurred in both interventions. In a second step, they independently categorized the factors. All disagreements were then resolved by a third rater (CW). After the disagreements were resolved, two authors (CW and KH) reviewed the categories of non-specific factors and subsumed them into 14 main categories.

It was possible for an item to be listed in several categories. Physiotherapy, for example, was included in category 1, “physical activity,” but also in category 2, “therapeutic aspects.” Moreover, it was possible to code the same item as both specific and non-specific factor. The reason for this is because it was possible that in one study a factor was considered as specific and in another study as a non-specific factor depending on the study design. For example, if the animal was only present in the experimental condition but not in the control condition in one study, we categorized “animal” as a specific factor. However, if the animal was also present in the control condition, then “animal” was categorized as a non-specific factor.
RESULTS

Search Results
We identified 2,001 reports and screened 1,893 titles and abstracts after we had removed duplicates. We assessed the full text of 525 reports for eligibility. In the end, 172 studies, which were published in 176 reports, fulfilled our inclusion criteria and were included in this systematic review (see Figure 1).

Study Characteristics
The included studies were published in records between 1987 and 2022. Of these, 76.14% (n = 134) were published between 2014 and 2022; 164 were peer-reviewed and published as journal articles, and only six were not published.

The majority of the reports (n = 116) were conducted in the USA (n = 74), Germany (n = 13), South Korea (n = 12), Spain (n = 9), or Italy (n = 8). Regarding the animals, a large majority of the studies used dogs (n = 107) or horses (n = 50), followed by cats (n = 7), guinea pigs (n = 6), or farm animals (n = 6) such as donkeys, goats, sheep, chickens, pigs, and rabbits (see Table 1 for an overview of the study characteristics).

Factor Hypotheses
We defined the following eleven categories, sorted by frequency: (1) human–animal interaction, (2) not specified, (3) movement by the animal, (4) social facilitator or catalyst, (5) relationship with an animal, (6) other, (7) presence of an animal, (8) physical contact, (9) social or emotional support, (10) taking care of an animal, (11) physical activity (see Table 2; Figure 2). Detailed information about each factor-hypothesis category can be found in the Supplementary Material S2.

Human–Animal Interaction
This category subsumed hypotheses that held the positive impact of human–animal interaction in general as responsible for the effects of AAIs. For example, authors stated that the interaction with an animal can reduce human stress (e.g., Barker et al., 2016; Fiocco and Hunse, 2017) or anxiety (e.g., Crossman et al., 2015; Foerder and Royer, 2021) or increase oxytocin levels (e.g., Chen et al., 2021). We found that 32.56% (n = 56) of the analyzed studies hypothesized human–animal interaction to be the working mechanism of AAIs.

Not Specified
This category contained studies where the authors did not specify possible mechanisms, made general assumptions, or mentioned different mechanisms in their introduction without specifying in the end what they hypothesized to be the working mechanism. For example, if authors mentioned that AAIs can lead to stress...
TABLE 1 | Study characteristics.

| First author | Year | Country | Type of publication | Animals | Control condition | Intervention |
|---------------|------|---------|---------------------|---------|-------------------|-------------|
| Abdel-Aziem   | 2022 | Saudi Arabia | Journal article | Horse | Physiotherapy (Schroth exercises) | Hippotherapy plus home workout exercises |
| Alemdaroglu   | 2016 | Turkey | Journal article | Horse | Conventional rehabilitation | Horseback riding plus therapist-directed exercises |
| Allen         | 2021 | USA | Journal article | Dog | Trauma-Focused Cognitive-Behavioral Therapy (TF-CBT) | TF-CBT with AAT as adjunctive therapy |
| Ambrozy       | 2017 | Poland | Journal article | Horse | Physical education classes | Horse’s walk and horse’s trot |
| An            | 2021 | South Korea | Journal article | Dog | Gait training | Gait training with dog |
| Antonioli     | 2005 | Honduras | Journal article | Dolphin | Outdoor nature program (water activities) | Play, swim, and take care of the animals |
| Aranda-Garcia | 2015 | Spain | Journal article | Horse | Two control condition: (a) traditional exercise program or (b) CG: none | Fun-oriented exercise and body workouts involving the horse |
| Ashari        | 2018 | Iran | Journal article | Dolphins | Training and playing in water | Interaction and swimming with dolphins |
| Asqarova      | 2021 | USA | Dissertation | Guinea pig | Reading session | Guinea pig therapy |
| Bachi         | 2014 | USA | Dissertation | Horse | Correctional and vocational programs | Equine-assisted intervention |
| Bailey        | 1987 | USA | Dissertation | Dog | Two control conditions: (a) structured curriculum about pets and pet care; (b) small group activities unrelated to the pet curriculum | A humane education curriculum guide and interaction with puppy |
| Banks         | 2008 | USA | Journal article | Dog | Two control conditions: (a) visit of the robot dog AIBO or (b) no intervention | Sitting in chair or upright in bed with the dog next to the resident |
| Barak         | 2001 | Israel | Journal article | Dog and cat | Reading and discussing news in group | Taking care of dog or cat |
| Barker        | 2020 | USA | Journal article | Dog | Waiting room without animal | AAI with dog |
| Barker        | 2016 | USA | Journal article | Dog | Attention-control condition (completing the Family Life-Space Diagram) | Free interaction with dog |
| Barker        | 2003 | USA | Journal article | Dog | Reading magazines for 15 min | Conversation with dog handler, interaction with dog |
| Beck          | 2012 | USA | Journal article | Dog | Occupational therapy life skills classes | Interaction with dog and obedience |
| Becker        | 2017 | USA | Journal article | Dog | Social skills training | Animal-assisted Social Skills Training group activity with dog |
| Beetz         | 2012 | Germany | Journal article | Dog | Two control conditions: trier social stress test with (a) toy-dog or (b) friendly female student | Trier social stress test in the presence of a dog |
| Beetz         | 2015 | Germany | Journal article | Horse | Conventional play-based early intervention (PBl) | Riding and different activities on the horse |
| Beinotti      | 2013 | Brazil | Journal article | Horse | Physiotherapy | Touching animal or reaching for an object |
| Beinotti      | 2010 | Brazil | Journal article | Horse | Physiotherapy | Hippotherapy |
| Benda         | 2003 | USA | Journal article | Horse | Sitting astride the barrel and watched a horse video | Horseback riding |
| Berget        | 2008 | Norway | Journal article | Farm animals | Ordinary psychiatric treatment | Working with farm animals |
| Berry         | 2012 | Italy | Journal article | Dog | Physical therapy/socialization group | Physical therapy session or social session with a dog |
| Bialoszewski  | 2011 | Poland | Journal article | Horse | Home-based rehabilitation | Exercises with the horse at walk, trot, or while standing in place |
| Binet         | 2022 | USA | Journal article | Dog | Handler-only interaction | Canine assisted intervention with or without physical contact |
| Bowin         | 2020 | USA | Dissertation | Dog | Cold pressor test without dog present | Cold pressor test with physical contact to dog afterwards |
| Boyer         | 2014 | USA | Journal article | Cat | Toy cat activity | Interaction and taking care of cat |
| Branson       | 2017 | USA | Journal article | Dog | Plush stuffed dog | Interaction with therapy dog |

(Continued)
TABLE 1 | Continued

| First author          | Year | Country  | Type of publication | Animals | Control condition | Intervention                                                                 |
|-----------------------|------|----------|---------------------|---------|-------------------|------------------------------------------------------------------------------|
| Bravo Gonçalves       | 2020 | Brazil   | Journal article     | Horse   | Walking alongside a horse | Hippotherapy with blanket or saddle mount                                   |
| Breitenbach           | 2009 | Germany  | Journal article     | Dolphins/ (farm animals) | Three control conditions: (a) interaction with dolphins, (b) farm animals or (c) no treatment | Dolphin assisted-therapy sessions (different stages: introduction, interaction, play, direct contact, swim) |
| Bunketorp             | 2012 | Sweden   | Journal article     | Horse   | Rhythm and music-based therapy | Therapeutic riding                                                          |
| Bunketorp             | 2019 | Sweden   | Journal article     | Horse   | Music-based therapy | Hippotherapy                                                               |
| Calvo                 | 2016 | Spain    | Journal article     | Dog     | Choosing a single activity (art therapy, group sports, dynamic psycho-stimulation or gymnastics) | Interaction with therapy dog                                                      |
| Capparelli            | 2020 | USA      | Journal article     | Dog     | Interview          | Interview with a dog in the room                                            |
| Charnetski            | 2004 | USA      | Journal article     | Dog     | Two control conditions: (a) petting stuffed animal or (b) sitting comfortable on couch | Petting a real-life dog                                                       |
| Chen                  | 2021 | Taiwan   | Journal article     | Dog     | Non-animal related intervention | AAT group with dog                                                          |
| Cho                   | 2017 | South Korea | Journal article | Horses | Mechanical horseback riding | Horseback riding                                                            |
| Clark                 | 2020 | USA      | Journal article     | Dog     | Visit handler only  | Visit of dog and handler                                                   |
| Cole                  | 2007 | USA      | Journal article     | Dog     | Two control condition: (a) visit volunteer or (b) usual care | Patients may pet the dog and talk to the dog and volunteer                     |
| Colombo               | 2006 | Italy    | Journal article     | Canary  | Two control condition: (a) receiving plant or (b) receiving nothing | Look after Canary                                                            |
| Costa                 | 2019 | Brazil   | Journal article     | Dog     | Speech Therapy      | Speech Therapy Program with Dog                                              |
| Crossman              | 2015 | USA      | Journal article     | Dog     | Two control conditions: (a) viewing images of dog or (b) no treatment control | Free interaction with dog (petting, playing etc.)                               |
| Crump                 | 2015 | USA      | Journal article     | Dog     | Study 1: non-stressful activities // Study 2: drawing activities. | Animal-assisted activity with a dog                                           |
| Dietz                 | 2012 | USA      | Journal article     | Dog     | Two control conditions: (a) no dog, (b) no story, dog present | Group therapies with dogs integrated in stories                               |
| Dunlap                | 2020 | USA      | Dissertation        | Fish    | Empathy-based mini lessons in classroom | Empathy-based lessons with pet fish                                          |
| Eckes                 | 2020 | Germany  | Journal article     | Mice    | Biology lessons     | Care treatment and lesson with mice                                          |
| El-Maniawy            | 2012 | Egypt    | Journal article     | Horse   | Designed exercise programm | Horseback riding                                                            |
| Fiocco                | 2017 | Canada   | Journal article     | Dog     | Relax in a seated position for 10 min | Free interaction with therapy dog                                          |
| Flynn                 | 2019 | USA      | Journal article     | Dog     | Intensive family preservation services | AAT as adjunctive to IFPS                                                    |
| Foerder               | 2021 | USA      | Journal article     | Dog     | Waiting with stuffed dog/waiting with research assistant | Waiting room with dog                                                       |
| Friedmann             | 2015 | USA      | Journal article     | Dog     | Attentional control intervention | Skills taught/reinforced with different components of the dog visit program include: feeding, brushing etc. |
| Funakoshi             | 2018 | Japan    | Journal article     | Horse   | Exercise using the horseback riding simulator | Horseback riding                                                             |
| Fung                  | 2014 | Hong Kong | Journal article     | Dog     | Identical play therapy procedure using a doll | Play therapy with a dog                                                      |
| Gabriels              | 2015 | USA      | Journal article     | Horse   | Barn activity       | Therapeutic horseback riding                                                |
| Gabriels              | 2018 | USA      | Journal article     | Horse   | Barn activity       | Therapeutic horseback riding                                                |
| Germone               | 2019 | USA      | Journal article     | Dog     | Novel toy and handler control | Animal-assisted activities in small groups                                   |
| Gocheva               | 2018 | Switzerland | Journal article | Suitable animal | Standard therapy session | AAT                                                                                 |
| Gee                   | 2019 | USA      | Journal article     | Fish    | Two control conditions: (a) viewing plants and water; (b) viewing empty tank | Viewing fish tank                                                            |
| Grajforner            | 2017 | UK       | Journal article     | Dog     | Two control conditions: (a) interaction with the dog or (b) interaction with the handlers only | Interaction with dog and handler only                                          |

(Continued)
| First author          | Year | Country         | Type of publication | Animals | Control condition                                      | Intervention                                                                 |
|-----------------------|------|-----------------|---------------------|---------|--------------------------------------------------------|------------------------------------------------------------------------------|
| Grubbs                | 2016 | USA             | Journal article     | Dog     | Exercise group                                         | Exercise group with dogs and animal-assisted team                            |
| Gebhart               | 2020 | Austria         | Journal article     | Dog     | Distraction-focused interventions                      | Animal-assisted intervention with therapy dogs                               |
| Hansen                | 1999 | USA             | Journal article     | Dog     | Usual pediatric exam without a dog present             | Pediatric examination in the presence of a dog                                |
| Hartfiel              | 2017 | Germany         | Journal article     | Dog     | Group therapy                                          | Therapy session with animal                                                  |
| Hartwig               | 2017 | USA             | Journal article     | Dog     | Interactive and activity-based curriculum              | Canine-assisted therapy based curriculum in HART intervention               |
| Havener               | 2001 | USA             | Journal article     | Dog     | Dental procedure                                       | Contact/interaction with a dog during dental procedure                       |
| Hediger               | 2019 | Switzerland     | Journal article     | Dogs,   | Conventional therapy session                          | Different therapies including an animal                                       |
|                      |      |                 |                     | rabbits, sheep, goats, miniature pigs, cats, chickens, rabbits and guinea pigs |                                                            |
| Henry                 | 2015 | USA             | Journal article     | Dog     | Exercises involving focus on the body and physical movement | Intervention with dog                                                       |
| Hernandez-Espeso      | 2021 | Spain           | Journal article     | Dolphin | Therapy without dolphins                               | Dolphin-assisted therapy and interaction with the therapist and the dolphin trainer |
| Hession               | 2019 | Ireland         | Journal article     | Horses  | Two control conditions: (a) audiovisual intervention or (b) waitlist | Horseback riding intervention                                               |
| Heyer                 | 2014 | Germany         | Journal article     | Dog     | Reading with plush dog                                 | Reading with dog (active involvement of the dog)                            |
| Hinic                 | 2019 | USA             | Journal article     | Dog     | Completed a jigsaw puzzle depicting an underwater scene with a research assistant and parent | Pet therapy with handler and dog, interaction with dog                       |
| Holman                | 2020 | USA             | Journal article     | Dog     | CBT manualized psychoeducational intervention         | Canine-assisted therapy                                                    |
| Hunt                  | 2014 | USA             | Journal article     | Dog     | Two control conditions: (a) write about a negative or traumatic event or (b) described in detail the dimensions and furnishings of three different rooms in three writing sessions | Writing in the presence of a dog                                              |
| Hyeon Su              | 2014 | South Korea     | Journal article     | Horse   | Trunk stability exercise                               | Horseback riding                                                            |
| Janura                | 2015 | Czech Republic  | Journal article     | Horse   | Physiotherapy                                          | Hippotherapy in addition to standard physiotherapy                            |
| Jaspersen             | 2013 | USA             | Journal article     | Dog     | Group therapy                                          | Intervention with dog                                                       |
| Johnson               | 2008 | USA             | Journal article     | Dog     | Two control conditions: (a) friendly human visit or (b) quiet reading group | Dog visit                                                                   |
| Julius                | 2013 | Germany         | Journal article     | Guinea pig | HeartMath (HM) mindfulness-based intervention        | Therapeutic horseback riding                                               |
| Kemeny                | 2021 | USA             | Journal article     | Horse   | Horse riding simulator (HRS)                           | Horseback riding                                                            |
| Kim                   | 2016 | South Korea     | Journal article     | Horse   | Simulated horseback riding                            | Horseback riding                                                            |
| Kim                   | 2018 | South Korea     | Journal article     | Horse   | Treadmill Training                                    | Horseback riding                                                            |
| Kim                   | 2014 | South Korea     | Journal article     | Horse   | Coloring a mandala                                    | Interaction with therapy dog                                                |
| Kline                 | 2020 | USA             | Journal article     | Dog     | Lectures that focused on healthy lifestyle choices    | Taking care of crickets                                                     |
| Ko                    | 2016 | South Korea     | Journal article     | Insects (crickets) | Standard outpatient physical therapy (PT)             | AAI-canine in forensic interview                                             |
| Kraft                 | 2019 | USA             | Journal article     | Horse   | Standard forensic interview                           |                                                                             |
| Krause-Parello        | 2015 | USA             | Journal article     | Dog     | Standard forensic interview                           |                                                                             |
| First author | Year | Country         | Type of publication | Animals | Control condition                                                                 | Intervention                                                                 |
|--------------|------|-----------------|---------------------|---------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Krause-Parello | 2019 | USA             | Journal article     | Dog     | Informational session about assistance dogs                                        | Intervention with handler and therapy dog                                      |
| Kwangmin Ryu  | 2016 | South Korea     | Journal article     | Horse   | Two control conditions: (a) aquatic movement therapy or (b) watching a movie       | Horseback riding                                                              |
| Kwon          | 2015 | South Korea     | Journal article     | Horse   | Home-based aerobic exercise                                                         | Hippotherapy and active exercises                                               |
| Lahav         | 2019 | Israel          | Journal article     | Dog     | Group intervention (solving problems and group sport)                              | Intervention with dog (educational topics about dog, getting to know the dog, interaction, practical training) |
| Lanning       | 2014 | USA             | Journal article     | Horse   | Educational and recreational activities                                             | Dog-assisted activity to improve riding and horsemanship skills                |
| Lang          | 2010 | Germany         | Journal article     | Dog     | A 30 min talk with the same research assistant                                    | Dog-assisted interview                                                        |
| Lass-Hennemann| 2018 | Germany         | Journal article     | Dog     | Two control conditions: (a) watching a 15-min film of a person interacting with one of the therapy dogs or (b) relaxing | Interaction with dog after traumatic film clip (physical contact was encouraged) |
| Lass-Hennemann| 2014 | Germany         | Journal article     | Dog     | Three control conditions: (a) watching clip with friendly human, (b) watching clip with toy-animal or (c) watching clip alone | Interaction with physical contact with dog during trauma film                  |
| LeRoux        | 2014 | South Africa    | Journal article     | Dog     | Tree control conditions: (a) reading to an adult, (b) reading to a teddy bear or (c) no intervention | Interacting with and reading out loud to dog                                    |
| Lechner       | 2007 | Switzerland     | Journal article     | Horse   | Three control conditions: (a) sitting astride on Bobath Roll, (b) sitting on a rocker board (inside of a wooden stool) or (c) received no intervention | Horseback riding                                                              |
| Lee           | 2014 | South Korea     | Journal article     | Horse   | Treadmill                                                                         | Hippotherapy                                                                    |
| Lenihan       | 2016 | USA             | Journal article     | Dog     | Reading to adult volunteer                                                        | Weekly reading to same dog                                                     |
| Levinson      | 2017 | USA             | Journal article     | Dog     | Reading to peers                                                                  | Reading to dog                                                                 |
| Machova       | 2019 | Czech Republic  | Journal article     | Dog     | Standard physiotherapy and occupational therapy                                    | Supplement of AAT                                                              |
| Machova       | 2018 | Czech Republic  | Journal article     | Dog     | Conventional speech therapy                                                       | Speech therapy with a dog                                                      |
| Machova       | 2020 | Czech Republic  | Journal article     | Dog     | Relaxation technique                                                              | AAA with a dog                                                                 |
| Machova       | 2019 | Czech Republic  | Journal article     | Dog     | Two control conditions: (a) normal working process without a break or (b) normal working process with a break of choice | Work break in the presence of a dog                                           |
| Marr          | 2000 | USA             | Journal article     | Dogs, rabbits, ferrets, and guinea pigs | Substance abuse education group |
| Martos-Montes | 2020 | Spain           | Journal article     | Dog     | Toy dog                                                                           | Animal visit, free interaction with animal                                      |
| Matsuura      | 2020 | Japan           | Journal article     | Horse   | Stuffed toy horse                                                                | Human-dog interaction                                                          |
| Matusiak-Wieczorek | 2020 | Poland          | Journal article     | Horse   | Less sessions of hippotherapy                                                      | AAT with horse                                                                 |
| Menna         | 2016 | Italy           | Journal article     | Dog     | Two control conditions: (a) activities based on the formal reality orientation (ROT) group or (b) no activities | AAT intervention with dog                                                     |
| Menna         | 2019 | Italy           | Journal article     | Dog     | Formal reality orientation (ROT) intervention without the dog                     | AAT with dog                                                                  |
| Mossello      | 2011 | Italy           | Journal article     | Dog     | Control activity with plush dogs                                                  | Interaction with dog                                                           |
| Muela         | 2017 | Spain           | Journal article     | Dog, horses; cats and farm animals (such as sheep, goats, chickens, and pigs) | Standard daily routine and psychotherapy                                       |

(Continued)
### TABLE 1 | Continued

| First author | Year | Country | Type of publication | Animals | Control condition | Intervention |
|--------------|------|---------|---------------------|---------|-------------------|-------------|
| Mueller      | 2021 | USA     | Journal article     | Dog     | Two control conditions: (a) stuffed toy dog or (b) social interaction with animal | Social interaction and physical contact with a therapy dog |
| Munoz-Lasa   | 2011 | Spain   | Journal article     | Horse   | Physiotherapy     | Horseback riding |
| Murry        | 2012 | USA     | Journal article     | Reptile | The control group discussed death and grief without reference to, or interactions with, reptiles. | Reptile-assisted support group discussed death and grief along with training in animal care |
| Mutch        | 2019 | Japan   | Journal article     | Horse   | Outdoor recreation program | Hippotherapy |
| Nathans-Barel| 2005 | Israel  | Journal article     | Dog     | General discussions, learning about caring for animals, particularly dogs, and walks on hospital grounds with the therapist for similar periods as in the active group. | AAT with dog (interaction and activities) |
| Ngai         | 2021 | Hong Kong| Journal article     | Dog     | School program    | Competence in Active Resilience for Kids (CARing Kids) humane education with animal-assisted SEL |
| Nilsson      | 2015 | Sweden  | Journal article     | Dog     | Visits only by researchers | Visits by researchers with an additional visit by a therapy dog and its handler. |
| Nurenberg    | 2015 | USA     | Journal article     | Horses, dogs | Two control conditions: (a) environmentally enhanced social skills group psychotherapy (SSP) or (b) regular hospital care (standard control) | Equine-assisted-therapy |
| Odendaal     | 2001 | USA     | Dissertation        | dog     | Read a book       | Contact to dog (stroking) |
| O’Haire      | 2015 | Australia| Journal article    | Guinea pigs | Three control conditions: (a) playing with toys, (b) reading aloud or (c) reading silently | Freestyle with peers and animals |
| Oh           | 2018 | South Korea| Journal article     | Horse   | Pharmacotherapy  | Hippotherapy |
| Palsdottir   | 2020 | Sweden  | Journal article     | Horse   | Physical activity | Equine-assisted intervention |
| Pan          | 2019 | USA     | Journal article     | Horse   | Pony-sized stuffed horse, to practice activities (e.g., grooming and tacking) | Therapeutic horseback riding |
| Park         | 2019 | South Korea| Journal article     | Cricket | Auditory effects of pet crickets and telephone counseling | Insect-rearing |
| Pendry       | 2019 | USA     | Journal article     | Dog     | Academic Stress Management (ASM) | Interaction with therapy dog and handler or anti-stress management with dog |
| Pendry       | 2019a| USA     | Journal article     | Dog or cat | Two control conditions: (a) Watching others pet animal or (b) viewing visuals of animals | Animal visitation program with dog or cat |
| Pendry       | 2020b| USA     | Journal article     | Dog     | Academic stress management (ASM) | Interaction with therapy dog and handler or ASM with dog |
| Pendry       | 2021b| USA     | Journal article     | Dog     | Academic stress management (ASM) | Interaction with therapy dog and handler or anti-stress management with dog |
| Pendry       | 2020 | USA     | Journal article     | Dog     | Academic stress management (ASM) | Interaction with therapy dog and handler or ASM with Dog |
| Pendry       | 2019a| USA     | Journal article     | Dog or cat | Two control conditions: (a) watching others pet animals or (b) viewing slideshow with animals | Animal visitation program with dog or cat |
| Peters       | 2021c| USA     | Journal article     | Horse   | Occupational therapy in a garden | Equine-assisted therapy |
| Peters       | 2021c| USA     | Journal article     | Horse   | Occupational therapy in a garden | Equine-assisted therapy |
| Petty        | 2017 | USA     | Journal article     | Horse   | Learning about horses | Horseback riding |
| Polheber     | 2014 | USA     | Journal article     | Dog     | Two control conditions: (a) speaking with their good friend or (b) sit quietly and wait | Interaction with dog |

(Continued)
## Table 1 Continued

| First author          | Year | Country | Type of publication | Animals | Control condition                                                                 | Intervention                                                                 |
|-----------------------|------|---------|---------------------|---------|----------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Rawleigh              | 2021 | Canada  | Journal article     | Dog     | Two control conditions: (a) a dog visitation program or (b) counseling             | Dog training and vocational program                                          |
| Richeson              | 2003 | USA     | Journal article     | Dog     | Two control conditions: (a) human visitor or (b) no visitors                      | Intervention with dog and handler                                             |
| Rodrigo-Claverol      | 2019 | Spain   | Journal article     | Dog     | Kinesitherapy                                                                    | Therapeutic exercises with animal                                             |
| Rodrigo-Claverol      | 2020 | Spain   | Journal article     | Dog     | Physiotherapy                                                                    | Physiotherapy + supplement of AAT                                             |
| Ruiz                  | 2011 | Croatia | Journal article     | Dog     | Daily walk                                                                       | Dog-walking                                                                    |
| Santaniello           | 2020 | Italy   | Journal article     | Dog     | Formal reality orientation therapy (ROT)                                        | AAT interventions adapted to the formal ROT                                   |
| Scheidhacker          | 2002 | Germany | Journal article     | Horse   | Horseback riding lesson                                                          | Therapeutic horseback riding                                                  |
| Schneider             | 2016 | Canada  | Journal article     | Horse   | Therapeutic skiing                                                               | Riding lessons                                                                 |
| Schuck                | 2015 | USA     | Journal article     | Dog     | Two control conditions: (a) cognitive-behavioral intervention or (b) waitlist      | Intervention with therapy dog and handler                                     |
| Schuck                | 2018 | USA     | Journal article     | Dog     | Two control conditions: (a) cognitive-behavioral intervention with toy dog or (b) waitlist | Animal-assisted intervention with dog and handler                              |
| Scorzato              | 2017 | Italy   | Journal article     | Dog     | Activity (substitution by an unanimated object)                                  | Dog-assisted treatment intervention                                           |
| Seivert               | 2014 | USA     | Journal article     | Dog     | Dog-walking                                                                       | Dog training and education component                                          |
| Smith                 | 2010 | USA     | Dissertation        | Dog     | Read aloud independently in an assigned area of the public library              | Reading sessions with therapy dog                                             |
| Souza-Santos          | 2018 | Brazil  | Journal article     | Horse   | Dance                                                                            | Horseback riding                                                             |
| Syzmanski             | 2018 | USA     | Journal article     | Dog     | Dog-walking                                                                       | Training of undersocialized dogs                                              |
| Temcharoensuk         | 2015 | Thailand| Journal article     | Horse   | Two control conditions: (a) mechanical horse-riding simulator while watching an animated movie or (b) horse riding simulator was powered off | Horseback riding                                                             |
| Tepper                | 2021 | Australia| Journal article    | Dog     | Two control conditions: (a) Dog present, (b) reading out loud to dog             | Training with dog                                                            |
| Thakkar               | 2021 | India   | Journal article     | Dog     | Dental treatment                                                                  | Dental treatment in the presence of a dog                                    |
| Thelwell              | 2019 | England | Journal article     | Dog     | Watching videos of dogs                                                           | 10 min free interaction with dog                                              |
| Thodberg              | 2016 | Denmark | Journal article     | Dog     | Two control conditions: (a) interacting with a robot seal (PARO) or (b) interacting with a soft toy cat | Intervention with real life dog                                               |
| Thodberg              | 2021 | Denmark | Journal article     | Dog     | Two control conditions: (a) Visits with a dog, no activity (D) or (b) Visits without dog, with an activity (A). | Dog visit with activity                                                      |
| Travers               | 2013 | Australia| Journal article     | Dog     | Human-therapist-only intervention with an article to stimulate discussion         | Intervention with dog                                                        |
| Trujillo              | 2020 | USA     | Journal article     | Dog     | Manual-standardized motivational interviewing and acceptance and commitment therapy, called impACT | AAT + impACT                                                                 |
| Urban                 | 2015 | Germany | Journal article     | Dog     | Walking with nurse                                                                | Dog walking                                                                   |
| Vagnoli               | 2015 | Italy   | Journal article     | Dog     | Venipuncture without dog present                                                 | Venipuncture with dog present                                                |
| Vandagriff            | 2021 | USA     | Journal article     | Cats and dogs                      | Three control conditions: (a) animal visit program proximit.; (b) animal visit program imaginary or (c) waitlist | Free interaction with dog and cats, engaging in petting and stroking (for 10 min) |
| Spruin                | 2021 | UK      | Journal article     | Cog      | Mindfulness condition                                                             | Pets As Therapy (PAT) dog                                                     |
| Vidal Prieto          | 2021 | Brasil  | Journal article     | Horse   | Hipotherapy once a week                                                          | Hipotherapy twice a week                                                      |
| Villalta-Gil          | 2009 | Spain   | Journal article     | Dog     | Integrated psychological treatment                                               | Intervention with dog                                                        |
| Voznesenskiy          | 2016 | Ecuador | Journal article     | Horses  | Regular adapted physical education activities                                   | Adaptive horseback riding                                                    |

(Continued)
relief but did not specify what leads to this stress relief (such as interacting with the animal), the hypothesis was categorized as not specified (e.g., Gocheva et al., 2018; Bunketorp-Kall et al., 2019; An and Park, 2021). The results show that 16.86% ($n = 29$) of the studies did not specify factor hypotheses.

Movement by the Animal
In this category, we subsumed hypotheses that assumed that movement by the animal is crucial for the effects of AAIs. This includes, for example, the movement or rhythm of a horse when riding (e.g., Ambrozy et al., 2017; Hession et al., 2019; Kraft et al., 2019). We found that authors of 24 studies mentioned movement as a mechanism for the effects of AAIs, which accounted for 13.95% of the analyzed studies.

Social Facilitator or Catalyst
In this category, we included studies that hypothesized that animals’ ability to act as social facilitators or catalysts has positive effects on humans. For example, authors hypothesized that animals enhance social learning in humans (Schuck et al., 2015) or foster human social communication and interaction skills (e.g., Barak et al., 2001; Flynn et al., 2019). The analyses revealed that 12.21% ($n = 21$) of the analyzed studies mentioned the animal as a social facilitator or catalyst as a possible mechanism for the effects of AAIs.

Relationship With an Animal
In this category, we subsumed hypotheses addressing the positive effect of relationships, attachment, or companionship between humans and animals. For example, some authors mentioned the positive effect of an attachment (e.g., Crump and Derting, 2015) or relationship established over time between a patient and an animal (Lanning et al., 2014). The results show that 16 studies mentioned the relationship between humans and animals as an explanation for the mechanisms of AAIs. This accounted for 9.3% of the analyzed studies.

Other
In this category, we summarized hypotheses that were not mentioned more than twice and did not match any other category. Examples include the biophilia hypothesis (e.g., Antonioli and Reveley, 2005; Gee et al., 2019) or the hypothesis that the sound of insects can create nostalgic feelings (Park et al., 2019). In total, we identified 15 studies with other factor hypotheses, which accounted for 8.72% of the analyzed studies.

Presence of Animal
In this category we included all studies that considered the presence of an animal as a possible mechanism of AAIs. For example, some claimed that the presence of an animal (in contrast to interacting with an animal) has a calming effect (Allen et al., 2021) or can distract from stressful situations (Hansen et al., 1999). We found that 6.98% ($n = 12$) of the studies mentioned the presence of an animal as a possible mechanism.

Physical Contact
This category encompassed hypotheses addressing physical contact with the animal as a possible mechanism of AAIs. For example, some authors suggested that petting an animal increases autonomic arousal (Vandagriff et al., 2021). We found that 10 studies mentioned physical contact as a possible mechanism of AAIs, which accounted for 5.81% of the analyzed studies.

Social or Emotional Support
In this category, we included hypotheses that animals can provide either social or emotional support to humans. An example is the suggestion that an animal can provide social support comparable to that of a human (Lass-Hennemann et al., 2014). Authors of six studies mentioned animals as social or emotional support as a hypothesis for the effects of AAIs. This accounted for 3.49% of the analyzed studies.

Taking Care of an Animal
In this category, we included studies where the authors hypothesized that the opportunity to take care of an animal can
| Author            | Year | Factor hypotheses | Specific factors | Non-specific factors                              |
|-------------------|------|-------------------|-----------------|--------------------------------------------------|
| Abdel-Aziem       | 2022 | Movement by the animal | Animal; movement by the animal | Physical activity; therapeutic aspects |
| Alemdaroğlu       | 2016 | Not specified     | Animal; movement by the animal | Physical activity |
| Allen             | 2021 | Presence of animal | Animal          | Therapeutic aspects; plush or toy animal |
| Ambrozy           | 2017 | Movement by the animal | Animal; movement by the animal | Physical activity; environment |
| An                | 2021 | Not specified     | Animal; interaction with an animal | Physical activity; therapeutic aspects |
| Antonioli         | 2005 | Other             | Animal; interaction with an animal, taking care of an animal | Physical activity; environment; social contact |
| Aranda-Garcia     | 2015 | Physical activity | Animal          | Physical activity |
| Ashtari           | 2018 | Relationship with an animal | Animal; interaction with an animal | Physical activity; environment; playing |
| Asqarova          | 2021 | Not specified     | Animal; interaction with an animal | Activity, distraction, or absorption; education/training |
| Antonioli         | 2005 | Social facilitator or catalyst; relationship with an animal | Animal; taking care of an animal | Social interaction; activity, distraction, or absorption |
| Aranda-Garcia     | 2014 | Relationship      | Animal          | Education/training |
| Bailey            | 1987 | Taking care of an animal | Animal; interaction with an animal | Social interaction; education or training |
| Banks             | 2008 | Relationship with an animal | Animal          | Social interaction; plush or toy animal |
| Barak             | 2001 | Social facilitator or catalyst; relationship with an animal | Animal; taking care of an animal | Social interaction |
| Barker            | 2020 | Not specified     | Animal; interaction with an animal; social interaction | Activity, distraction, or absorption |
| Barker            | 2016 | Human-animal interaction | Animal; interaction with an animal | Activity, distraction, or absorption |
| Barker            | 2003 | Human-animal interaction | Animal; social interaction; interaction with an animal | Activity, distraction, or absorption |
| Beck              | 2012 | Human-animal interaction | Animal; training an animal; physical contact; interaction with an animal | Therapeutic aspects |
| Becker            | 2017 | Social facilitator or catalyst; human-animal interaction | Animal; physical contact; training an animal; social interaction | Social interaction; education or training |
| Beetz             | 2012 | Social or emotional support | Animal; interaction with an animal; physical contact | Social interaction |
| Beetz             | 2015 | Social facilitator or catalyst; physical contact | Animal; interaction with animal, movement by the animal | Therapeutic aspects; social interaction; activity, distraction, or absorption |
| Beinotti          | 2013 | Movement by the animal; taking care of an animal; social facilitator or catalyst | Animal; physical contact | Physical activity |
| Beinotti          | 2010 | Movement by the animal | Animal; movement by the animal | Physical activity |
| Benda             | 2003 | Movement by the animal | Animal; movement by the animal | Activity, distraction, or absorption; interaction with something like an animal; relaxation; watching or seeing animal |
| Berget            | 2008 | Taking care of an animal; human-animal interaction | Animal; physical contact; taking care of an animal | Therapeutic aspects |
| Berry             | 2012 | Social facilitator or catalyst | Animal; interaction with an animal | Physical activity; therapeutic aspects; social interaction |
| Bialoszewski      | 2011 | Human-animal interaction | Animal; movement by the animal | Physical activity; therapeutic aspects |
| Binet             | 2022 | Physical contact  | Physical contact | Social interaction; animal |
| Bowin             | 2020 | Human-animal interaction | Animal; interaction with an animal | Activity, distraction, or absorption |
| Boyer             | 2014 | Social facilitator or catalyst | Animal | Plush or toy animal; interaction with something like an animal |
| Branson           | 2017 | Human-animal interaction | Animal          | Plush or toy animal; interaction with something like an animal; novelty |
| Bravo Gonçalves   | 2020 | Other (mount material) | Other (mount material) | Animal; interaction with something like an animal; physical activity |
| Breitenbach       | 2009 | Other (parental involvement) | Other (recreational/vacation atmosphere, therapeutic aspects) | Environment; animal; interaction with something like an animal |
| Bunketorp         | 2012 | Movement by the animal | Animal; movement by the animal, taking care of an animal | Therapeutic aspects; movement or rhythm |
| Bunketorp         | 2019 | Not specified     | Animal; interaction with animal | Therapeutic aspects; social interaction; movement or rhythm |

(Continued)
| Author    | Year | Factor hypotheses                                | Specific factors                                                                 | Non-specific factors                                                                 |
|-----------|------|-------------------------------------------------|----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| Calvo     | 2016 | Social facilitator or catalyst; human-animal interaction | Animal; interaction with an animal; training an animal; taking care of an animal | Physical activity; therapeutic aspects; social interaction; activity, distraction, or absorption |
| Capparelli| 2020 | Social facilitator or catalyst; social or emotional support | Animal; interaction with an animal; physical contact | Activity, distraction, or absorption |
| Chametski | 2004 | Physical contact; presence of animal              | Animal; physical contact                                                         | Plush or toy animal; interaction with something like an animal; relaxation            |
| Chen      | 2021 | Human-animal interaction; social or emotional support | Animal; interaction with an animal                                              | Therapeutic aspects; social interaction                                               |
| Cho       | 2017 | Movement by the animal                           | Animal                                                                          | Physical activity; interaction with something like an animal; movement or rhythm     |
| Clark     | 2020 | Human-animal interaction                          | Animal; interaction with an animal                                              | Social interaction                                                                    |
| Cole      | 2007 | Human-animal interaction; physical contact         | Animal; physical contact, interaction with an animal                           | Social interaction                                                                    |
| Colombo   | 2006 | Relationship with an animal                       | Animal                                                                          | Other (taking care/responsibility)                                                   |
| Costa     | 2019 | Human-animal interaction                          | Animal; interaction with an animal                                              | Therapeutic aspects                                                                  |
| Crossman  | 2015 | Human-animal interaction                          | Animal; interaction with an animal                                              | Watching or seeing animal                                                            |
| Crump     | 2015 | Human-animal interaction; physical contact; relationship with an animal | Animal; interaction with an animal; physical contact | Activity, distraction, or absorption; social interaction                              |
| Dietz     | 2012 | Not specified                                    | Other (integrating dog in story)                                                 | Animal; social interaction; therapeutic aspects                                      |
| Dunalp    | 2020 | Presence of animal                               | Animal                                                                          | Social interaction; education or training                                            |
| Eckes     | 2020 | Taking care of an animal                         | Animal; taking care of an animal                                                | Social interaction; education or training                                            |
| El-Maniawy| 2012 | Movement by the animal                           | Animal; movement by the animal                                                   | Physical activity                                                                    |
| Fiocco    | 2017 | Human-animal interaction                          | Animal; interaction with an animal                                              | Relaxation                                                                           |
| Flynn     | 2019 | Social facilitator or catalyst                   | Animal; interaction with an animal; taking care of an animal                    | Education or training                                                                |
| Foerder   | 2021 | Human-animal interaction                          | Animal; interaction with an animal                                              | Plush or toy animal; social interaction                                               |
| Friedmann | 2015 | Social facilitator or catalyst; social or emotional support | Animal                                                                           | Therapeutic aspects; social interaction; activity, distraction, or absorption        |
| Funakoshi | 2018 | Movement by the animal                           | Animal                                                                          | Physical activity; movement or rhythm, interaction with something like an animal     |
| Fung      | 2014 | Social facilitator or catalyst                   | Animal                                                                          | Therapeutic aspects; social interaction; activity, distraction, or absorption         |
| Gabriels  | 2015 | Human-animal interaction; relationship with an animal | Animal; movement by the animal; taking care of an animal, interaction with an animal | Plush or toy animal; education or training; therapeutic aspects; environment        |
| Gabriels  | 2018 | Human-animal interaction; relationship with an animal | Animal; movement by the animal; taking care of an animal, interaction with an animal | Plush or toy animal; education or training; therapeutic aspects; environment        |
| Germone   | 2019 | Social facilitator or catalyst                   | Animal; interaction with an animal                                              | Social interaction; activity, distraction, or absorption; novelty                    |
| Gocheva   | 2018 | Not specified                                    | Animal; interaction with an animal; taking care of an animal                    | Therapeutic aspects; physical activity; activity, distraction, or absorption         |
| Gee       | 2019 | Other (biophilia)                                | Animal; other (distraction presence of animal)                                  | Environment; activity, distraction, or absorption                                   |
| Grafommer | 2017 | Human-animal interaction                          | Interaction with an animal; social interaction                                  | Social interaction; animal                                                           |
| Grubbs    | 2016 | Social facilitator or catalyst                   | Animal; interaction with an animal; social interaction                          | Physical activity; social interaction                                                |
| Gebhart   | 2020 | Not specified                                    | Animal; interaction with an animal                                              | Movement or rhythm; activity, distraction, or absorption; social interaction; other (distraction) |
| Hansen    | 1999 | Presence of animal; other (distraction)           | Animal; interaction with an animal                                              | Therapeutic aspects                                                                  |
| Hartfield | 2017 | Social facilitator or catalyst                   | Animal                                                                          | Social interaction                                                                   |
| Hartwig   | 2017 | Not specified                                    | Animal                                                                          | Therapeutic aspects; social interaction                                              |
| Havener   | 2001 | Relationship with an animal; other (distraction) | Animal; interaction with an animal                                              | Therapeutic aspects                                                                  |
| Author | Year     | Factor hypotheses                      | Specific factors                                                                 | Non-specific factors                                      |
|--------|----------|----------------------------------------|----------------------------------------------------------------------------------|------------------------------------------------------------|
| Hediger| 2019     | Animal as social facilitator or catalyst| Animal                                                                          | Therapeutic aspects                                         |
| Hediger| 2019     | Not specified                          | Animal                                                                          | Therapeutic aspects                                         |
| Henry  | 2015     | Human-animal interaction                | Animal; interaction with an animal                                               | Physical activity; therapeutic aspects; activity, distraction, or absorption |
| Hernandez-Espeso| 2021 | Human-animal interaction                | Animal; interaction with an animal                                               | Environment; therapeutic aspects; social interaction         |
| Hession| 2019     | Movement by the animal                  | Animal; movement by the animal                                                   | Therapeutic aspects; movement or rhythm; watching or seeing animal |
| Heyer  | 2014     | Other (integrating real-life animal)    | Animal; interaction with an animal                                               | Plush or toy animal; activity, distraction, or absorption    |
| Hinic  | 2019     | Not specified                          | Animal; interaction with an animal                                               | Social interaction; activity, distraction, or absorption     |
| Holman | 2020     | Human-animal interaction                | Animal, interaction with an animal; physical contact; social interaction          | Therapeutic aspects                                         |
| Hunt   | 2014     | Social facilitator or catalyst          | Animal                                                                          | Activity, distraction, or absorption                         |
| Hyeon Su| 2014    | Movement by the animal                  | Animal; movement by the animal                                                   | Physical activity                                            |
| Janura | 2015     | Movement by the animal                  | Animal; movement by the animal                                                   | Therapeutic aspects; physical activity                      |
| Jasperson| 2013  | Human-animal interaction                | Animal; interaction with an animal                                               | Therapeutic aspects; social interaction; education          |
| Johnson| 2008     | Not specified                          | Animal; interaction with an animal; taking care of an animal; physical contact    | Social interaction; activity, distraction, or absorption     |
| Julius | 2013     | Human-animal interaction                | Animal                                                                          | Therapeutic aspects; education or training                  |
| Kemeny | 2021     | Human-animal interaction; other (large animal) | Animal; interaction with an animal; movement by the animal; relationship with an animal | Therapeutic aspects; relaxation                            |
| Kim    | 2016     | Not specified                          | Animal                                                                          | Physical activity; movement or rhythm; interaction with something like an animal |
| Kim    | 2018     | Physical activity                      | Animal                                                                          | Physical activity; movement or rhythm; interaction with something like an animal |
| Kim    | 2014     | Movement by the animal                  | Animal; movement by the animal                                                   | Physical activity                                            |
| Kline  | 2020     | Human-animal interaction                | Animal; interaction with an animal                                               | Activity, distraction, or absorption                         |
| Ko     | 2016     | Human-animal interaction                | Animal; taking care of an animal                                                 | Social interaction; education or training                   |
| Kraft  | 2019     | Movement by the animal                  | Animal; movement by the animal                                                   | Therapeutic aspects; physical activity                      |
| Krause-Parello| 2015 | Not specified                          | Animal; physical contact                                                         | Activity, distraction, or absorption                         |
| Krause-Parello| 2019 | Not specified                          | Animal; interaction with an animal                                               | Education or training                                       |
| Kwangmin Ryu| 2016 | Movement by the animal                  | Animal; movement by the animal                                                   | Physical activity; environment; activity, distraction, or absorption |
| Kwon   | 2015     | Movement by the animal                  | Animal; movement by the animal                                                   | Physical activity; therapeutic aspects                      |
| Lahav  | 2019     | Social facilitator or catalyst; presence of animal | Animal; training an animal; interaction with an animal; other (educational topics of animal); | Physical activity; social interaction, activity, distraction, or absorption |
| Lanning| 2014     | Movement by the animal; relationship with an animal | Animal; movement by the animal; taking care of an animal | Social interaction; activity, distraction, or absorption; education or training |
| Lang   | 2010     | Not specified                          | Animal; interaction with an animal                                               | Social interaction; other (talking about pet/animals)        |
| Lass-Hennemann| 2018 | Human-animal interaction                | Animal; interaction with an animal; physical contact                           | Watching or seeing animal; animal; interaction with something like an animal |
| Lass-Hennemann| 2014 | Social or emotional support; presence of animal | Animal; interaction with an animal; physical contact                           | Plush or toy animal; social interaction; activity, distraction, or absorption |
| LeRoux | 2014     | Not specified                          | Animal                                                                          | Plush or toy animal; social interaction; activity, distraction, or absorption |
| Lechner| 2007     | Movement by the animal                  | Animal; movement by the animal                                                   | Physical activity                                            |
| Lee    | 2014     | Movement by the animal                  | Animal; movement by the animal                                                   | Physical activity                                            |
| Lenihan| 2016     | Human-animal interaction                | Animal; relationship with the animal                                             | Social interaction; activity, distraction, or absorption     |
| Levinson| 2017    | Not specified                          | Animal                                                                          | Social interaction; activity, distraction, or absorption     |

(Continued)
| Author                  | Year  | Factor hypotheses                      | Specific factors                                                                 | Non-specific factors                                                                 |
|------------------------|-------|----------------------------------------|---------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| Machova                | 2019  | Presence of animal                     | Animal; interaction with an animal; relationship with an animal                  | Therapeutic aspects; physical activity                                               |
| Machova                | 2018  | Presence of animal                     | Animal; interaction with an animal; physical contact                             | Therapeutic aspects                                                                  |
| Machova                | 2020  | Human-animal interaction               | Animal; interaction with an animal                                              | Relaxation                                                                           |
| Machova                | 2019  | Presence of animal                     | Animal; interaction with an animal                                              | Relaxation                                                                           |
| Marr                   | 2000  | Social facilitator or catalyst         | Animal; interaction with an animal                                              | Social interaction; education or training                                            |
| Martos-Montes          | 2020  | Human-animal interaction               | Animal; interaction with an animal                                              | Plush or toy animal                                                                  |
| Matsuura               | 2020  | Physical contact                       | Physical contact                                                                 | Plush or toy animal; interaction with something like an animal; watching or seeing animal |
| Matusiak-Wiezorek      | 2020  | Not specified                          | Other (frequency)                                                               | Animal; movement or rhythm                                                           |
| Menna                  | 2016  | Relationship with an animal            | Animal; interaction with an animal                                              | Therapeutic aspects                                                                  |
| Menna                  | 2019  | Human-animal interaction; physical contact| Animal; interaction with an animal                                              | Therapeutic aspects                                                                  |
| Mossello               | 2011  | Physical contact                       | Animal                                                                          | Plush or toy animal; interaction with something like an animal                      |
| Muela                  | 2017  | Not specified                          | Animal                                                                          | Therapeutic aspects                                                                  |
| Mueller                | 2021  | Human-animal interaction; physical contact| Physical contact; interaction with an animal                                    | Plush or toy animal; novelty                                                          |
| Munoz-Lasa             | 2011  | Movement by the animal                 | Animal; movement by the animal                                                  | Physical activity; therapeutic aspects                                               |
| Murry                  | 2012  | Taking care of an animal               | Animal; taking care of an animal; another (education about animal)             | Social interaction; education or training                                            |
| Mutoh                  | 2019  | Movement by the animal                 | Animal; movement by the animal                                                  | Environment; activity, distraction, or absorption                                     |
| Nathans-Barel          | 2005  | Human-animal interaction               | Animal; interaction with an animal                                              | Physical activity; social interaction, education or training                          |
| Ngai                   | 2021  | Not specified                          | Animal; interaction with an animal                                              | Education or training                                                                 |
| Nilsson                | 2015  | Human-animal interaction               | Animal; interaction with an animal; physical contact                            | Social interaction                                                                  |
| Nurenberg              | 2015  | Not specified                          | Animal; interaction with an animal; training animal                              | Therapeutic aspects; environment; social interaction                                |
| Odendaal               | 2001  | Human-animal interaction               | Other (familiarity)                                                             | Activity, distraction, or absorption                                                |
| O’Haire                | 2015  | Social facilitator or catalyst         | Animal; interaction with an animal                                              | Social interaction; activity, distraction, or absorption                             |
| Oh                     | 2018  | Human-animal interaction               | Animal; movement by the animal                                                  | Therapeutic aspects                                                                  |
| Palsdottir             | 2020  | Not specified                          | Animal; movement by the animal; social interaction                             | Physical activity                                                                   |
| Pan                    | 2019  | Human-animal interaction               | Animal; movement by the animal                                                  | Plush or toy animal; activity, distraction, or absorption; interaction with something like an animal |
| Park                   | 2019  | Other (animal can create nostalgia feeling) | Animal; taking care of an animal                                               | Other (sound of animal); therapeutic aspects                                        |
| Pendry                 | 2019  | Human-animal interaction               | Animal; interaction with an animal                                              | Therapeutic aspects; physical activity, education or training                        |
| Pendry                 | 2019a | Human-animal interaction               | Interaction with an animal; social interaction                                | Activity, distraction, or absorption; watching or seeing animal; other (proximity)   |
| Pendry                 | 2020b | Human-animal interaction               | Animal; interaction with an animal                                              | Therapeutic aspects; activity, distraction, or absorption; education or training     |
| Pendry                 | 2021b | Human-animal interaction               | Animal; interaction with an animal                                              | Therapeutic aspects; activity, distraction, or absorption; education or training     |
| Pendry                 | 2020  | Human-animal interaction               | Animal; interaction with an animal                                              | Therapeutic aspects; activity, distraction, or absorption; education or training     |
| Pendry                 | 2019a | Human-animal interaction               | Interaction with an animal; social interaction                                | Activity, distraction, or absorption; watching or seeing animal; other (proximity)   |

(Continued)
| Author                  | Year   | Factor hypotheses                                                                 | Specific factors                                                                 | Non-specific factors                                                                 |
|------------------------|--------|------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Peters                 | 2021c  | Not specified                                                                      | Animal; interaction with an animal                                               | Therapeutic aspects; environment, social interaction; education or training; activity, distraction, or absorption |
| Peters                 | 2021c  | Human-animal interaction, social facilitator or catalyst                            | Animal; interaction with an animal                                               | Therapeutic aspects; environment; social interaction; education or training; activity, distraction, or absorption |
| Petty                  | 2017   | Human-animal interaction; relationship with an animal                              | Animal; movement by the animal; taking care of an animal                         | Education or training; environment; plush toy animal                                   |
| Polheber               | 2014   | Social or emotional support                                                        | Animal; interaction with an animal                                               | Social interaction                                                                    |
| Rawleigh               | 2021   | Human-animal interaction                                                           | Training an animal                                                               | Animal; therapeutic aspects                                                           |
| Richeson               | 2003   | Relationship with an animal                                                        | Animal; interaction with an animal                                               | Social interaction; activity, distraction, or absorption                                |
| Rodrigo-Claverol       | 2019   | Human-animal interaction                                                           | Animal                                                                          | Physical activity                                                                     |
| Rodrigo-Claverol       | 2020   | Not specified                                                                      | Animal; interaction with an animal                                               | Therapeutic aspects; physical activity; social interaction                            |
| Ruzic                  | 2011   | Physical activity                                                                  | Animal; taking care of an animal                                                 | Physical activity                                                                     |
| Santaniello            | 2020   | Human-animal interaction                                                           | Animal; interaction with an animal                                               | Therapeutic aspects                                                                  |
| Scheidhacker           | 2002   | Not specified                                                                      | Other (therapeutic aspects)                                                      | Animal; other (horseback riding)                                                    |
| Schneider              | 2016   | Human-animal interaction                                                           | Animal; movement by the animal                                                   | Physical activity; therapeutic aspects                                               |
| Schuck                 | 2015   | Social facilitator or catalyst; human-animal interaction                            | Animal                                                                          | Therapeutic aspects; plush or toy animal                                              |
| Schuck                 | 2018   | Human-animal interaction                                                           | Animal                                                                          | Therapeutic aspects; plush or toy animal                                              |
| Scorzato               | 2017   | Not specified                                                                      | Animal; interaction with an animal                                               | Activity, distraction, or absorption                                                 |
| Selvert                | 2014   | Human-animal interaction                                                           | Training an animal; relationship with an animal                                  | Animal; physical activity                                                             |
| Smith                  | 2010   | Not specified                                                                      | Animal                                                                          | Activity, distraction, or absorption                                                  |
| Souza-Santos           | 2018   | Physical activity                                                                  | Animal; physical contact; movement by the animal                                 | Physical activity; social interaction                                                  |
| Syzmanski              | 2018   | Human-animal interaction                                                           | Training an animal                                                               | Animal; physical activity                                                             |
| Temcharoensuk          | 2015   | Movement by the animal                                                             | Animal                                                                          | Physical activity; activity, distraction, or absorption; interaction with something like an animal |
| Tepper                 | 2021   | Human-animal interaction                                                           | Training an animal                                                               | Animal                                                                               |
| Thakkar                | 2021   | Physical contact                                                                   | Animal                                                                          | Therapeutic aspects                                                                  |
| Thelwell               | 2019   | Human-animal interaction                                                           | Animal; interaction with an animal                                               | Watching or seeing animal                                                             |
| Thodberg               | 2016   | Human-animal interaction                                                           | Animal                                                                          | Plush or toy animal; interaction with something like an animal                       |
| Thodberg               | 2021   | Presence of animal                                                                | Other (combination of activity with dog)                                         | Animal; physical contact; activity, distraction, or absorption                       |
| Travers                | 2013   | Social facilitator or catalyst; physical contact                                   | Animal; interaction with an animal                                               | Social interaction; other (bringing article to stimulate discussion)                  |
| Trujillo               | 2020   | Social facilitator or catalyst                                                     | Animal                                                                          | Therapeutic aspects                                                                  |
| Urban                  | 2015   | Not specified                                                                      | Animal                                                                          | Physical activity; social interaction; environment                                    |
| Vagnoli                | 2015   | Not specified                                                                      | Animal                                                                          | Therapeutic aspects                                                                  |
| Vandagriff             | 2021   | Physical contact                                                                   | Physical contact; interaction with an animal                                     | Animal; watching or seeing animal; other (proximity)                                  |
| Spruin                 | 2021   | Not specified                                                                      | Animal; interaction with an animal                                               | Activity, distraction, or absorption; relaxation                                       |
| Vidal Prieto           | 2021   | Movement by the animal                                                             | Other (frequency)                                                                | Animal; movement or rhythm                                                           |
| Villa-Gil              | 2009   | Not specified                                                                      | Animal; interaction with an animal                                               | Therapeutic aspects; social interaction                                               |
| Voznesenskiy           | 2016   | Physical activity                                                                  | Animal; movement by the animal                                                   | Physical activity                                                                    |
| Wanser                 | 2020   | Relationship with an animal                                                        | Training an animal                                                               | Animal; physical activity                                                             |
| Wesenberg              | 2019   | Presence of animal                                                                | Animal; physical contact; taking care of an animal; training of an animal        | Physical activity; social interaction                                                 |
| Wesley                 | 2009   | Social facilitator or catalyst                                                     | Animal                                                                          | Therapeutic aspects; social interaction                                               |

(Continued)
enhance the effects of AAIs (e.g., Murry and Allen, 2012; Eckes et al., 2020). We found five studies where authors mentioned this as a potential mechanism of AAIs. This accounted for 2.91% of the analyzed studies.

**Physical Activity**

We subsumed hypotheses about the importance of physical activity for the effects of AAIs in this category. For example, some authors suggested that exercising with animals (e.g., walking with an animal) leads to an effect (Aranda-Garcia et al., 2015). In total, 2.91% (n = 5) of the analyzed studies mentioned physical activity as a possible mechanism of AAIs.

**Specific Factors of AAIs**

We identified nine categories of specific factors of AAIs that were reflected in the control conditions of published AAI studies. Ordered by frequency, these categories were: (1) animal, (2) interaction with an animal, (3) movement by the animal, (4) physical contact, (5) taking care of an animal, (6) training an animal, (7) other, (8) social interaction, (9) relationship with an animal (see Table 2; Figure 3). A detailed description of all the categories of specific factors can be found in the Supplementary Material S3.

**Animal**

In the category “animal,” we included studies that had an experimental condition with a live animal and that compared that condition to a control condition with no animal present (e.g., Julius et al., 2013; Kim et al., 2016; Branson et al., 2017; Hartfiel et al., 2017; Levinson et al., 2017; Schuck et al., 2018; Wolynczyk-Gmaj et al., 2021; Abdel-Aziem et al., 2022). We found that 88.37% (n = 152) of the studies controlled for an animal as a specific factor.

**Interaction With an Animal**

Here we included studies with experimental conditions that contained a specific form of interaction with an animal, such as playing with an animal or free interaction (e.g., Hansen et al., 1999; Machova et al., 2019; Gebhart et al., 2020). We also included petting in this category if it was only mentioned as one of many ways that subjects could interact with an animal (e.g., Crump and Derting, 2015; Gocheva et al., 2018). If physical contact was part of the intervention—for example, if participants had to pet an animal—we categorized the factor under “physical contact” (e.g., Charnetski et al., 2004; Binfet et al., 2022). Further, in this category, we included studies that defined the reaction of the animal—such as sounds or other responses—as important for the interaction. Analyses revealed that 46.51% (n = 80) of the studies controlled for the interaction with an animal as a specific factor.

**Movement by the Animal**

In this category, we included studies with experimental conditions that incorporated movement by an animal as part of the intervention, such as while horseback riding (e.g., Lechner et al., 2007; Kim et al., 2014; Alemenoglu et al., 2016; Abdel-Aziem et al., 2022). We determined that 17.44% (n = 30) of the studies controlled for movement as a specific factor.

**Physical Contact**

In this category, we included studies with experimental conditions that specified physical contact with an animal, such as petting, as the factor in their intervention (e.g., Crump and Derting, 2015; Holman et al., 2020; Binfet et al., 2022). We found that 12.79% (n = 22) of the studies controlled for physical contact as a specific factor.

**Taking Care of an Animal**

Here, we included studies with experimental conditions where participants took care of an animal, for example, by grooming, feeding, or milking it (e.g., Berget and Braastad, 2008; Ko et al., 2016; Gocheva et al., 2018). Of the analyzed studies, 12.21% (n = 21) defined taking care of an animal as a specific factor.

**Training an Animal**

In this category, we included studies with experimental conditions where subjects could teach or train animals, for example, by giving animal commands (e.g., Rawleigh and Purc-Stephenson, 2021). We found that 11 studies included training animals as a specific factor, which accounted for 6.39% of the analyzed studies.

**Other**

Here we included studies with characteristics in their experimental conditions that did not match any other category and that were not mentioned more than twice. Examples in this category are mounting material (Bravo Gonçalves Junior et al., 2020), the familiarity of the animal (Odendaal, 2001), or the frequency of the intervention (Vidal Prieto et al., 2021). We

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**TABLE 2 | Continued**

| Author                  | Year  | Factor hypotheses                  | Specific factors                                          | Non-specific factors                  |
|-------------------------|-------|------------------------------------|----------------------------------------------------------|---------------------------------------|
| White-Lewis d)          | 2019  | Movement by the animal             | Animal; movement by the animal                           | Physical activity; education or training |
| White-Lewis d)          | 2018  | Movement by the animal             | Animal; movement by the animal, taking care of an animal; training an animal | Physical activity; education or training |
| Wolynczyk-Gmaj          | 2021  | Presence of animal                 | Animal                                                   | Physical activity; social interaction |
| Woolley                 | 2004  | Not specified                      | Animal, interaction with an animal; taking care of an animal | Therapeutic aspects; social interaction |
| Zisselman               | 1996  | Relationship with an animal        | Animal; interaction with an animal; social interaction   | Physical activity                    |
FIGURE 2 | Number of identified factor hypotheses.

FIGURE 3 | Number of identified specific factors.
found 11 studies that controlled for other specific factors. This accounted for 6.39% of the included studies.

Social Interaction
In this category, we included studies with experimental conditions where subjects engaged with other human beings, for example, in group activities or by talking to another person (e.g., Palsdottir et al., 2020; Asgarova, 2020). Analyses showed that 5.81% (n = 10) of the studies controlled for social interaction as a specific factor.

Relationship With an Animal
In this category, we included studies with experimental conditions where relationship-building between subjects and an animal was promoted, for example, when subjects could work for a longer time with one animal in order to build a relationship with the animal (e.g., Seivert, 2014). We found that 2.32% (n = 4) of the studies controlled for the relationship with the animal as a specific factor.

Non-specific Factors of AAIs
Comparing the control and the experimental condition in previously published studies, we identified the following 14 categories of non-specific factors, ordered by frequency: (1) therapeutic aspects, (2) social interaction, (3) physical activity, (4) activity, distraction, or absorption, (5) education or training, (6) plush or toy animal, (7) animal, (8) environment, (9) interaction with something like an animal, (10) movement or rhythm, (11) relaxation, (12) watching or seeing an animal, (13) other, and (14) novelty (see Table 2; Figure 4). Detailed information about the non-specific categories can be found in the Supplementary Material S4.

Therapeutic Aspects
In this category, we included studies with control conditions that contained therapeutic components, such as trauma-focused therapy (e.g., Allen et al., 2021), psychological treatment (e.g., Muela et al., 2017; Holman et al., 2020), or physiotherapeutic treatment (e.g., Beinotti et al., 2013; Rodrigo-Claverol et al., 2020). In total, 37.21% (n = 64) of the analyzed studies controlled for therapeutic aspects as a non-specific factor.

Social Interaction
Here we included studies with control conditions that contained contact or interaction with other humans, such as speaking to another human or playing group sports (e.g., Crump and Derting, 2015; Grubbs et al., 2016; Foerder and Royer, 2021). Analyses showed that 57 studies controlled for social contact or interaction as a non-specific factor. This accounted for 33.14% of the included studies.

Physical Activity
In this category, we included studies with control conditions that controlled for physical activity, such as rehabilitation exercises (e.g., Alemdaroglu et al., 2016), group sports (e.g., Calvo et al., 2016), or dance classes (e.g., Souza-Santos et al., 2018). We found that 51 studies controlled for physical activity as a non-specific factor. This accounted for 29.65% of the included studies.

Activity, Distraction, or Absorption
In this category, we subsumed studies with control conditions that offered an activity or that distracted or occupied participants or demanded their attention by, for example, having them read (e.g., Heyer and Beetz, 2014; Barker et al., 2020), color (e.g., Kline et al., 2020), or write (e.g., Hunt and Chizkova, 2014). Of the analyzed studies, 27.91% (n = 48) controlled for activity, distraction, or absorption as a non-specific factor.

Education or Training
Here we included studies with control conditions that contained educational aspects, such as social-skills training (e.g., Becker et al., 2017) or empathy training (e.g., Julius et al., 2013; Dunlap, 2020). We found that 15.17% (n = 26) of the studies controlled for education or training as a non-specific factor.

Plush or Toy Animal
In this category, we included all studies with control interventions that incorporated a plush or toy animal, such as a plush dog (e.g., Branson et al., 2017), toy dog (e.g., Martos-Montes et al., 2020), or stuffed plush horse (e.g., Gabriels et al., 2018). We found that 20 studies controlled for interacting with a plush or toy animal as a non-specific factor. This accounted for 11.63% of the included studies.

Animal
In this category, we included studies with control conditions where subjects had contact with a live animal but where the degree of contact and interaction varied. For example, in one study, the animal in the control condition was only present (compared to training with the animal in the experimental condition) (Tepper et al., 2021), or some studies compared control conditions in which subjects interacted with an animal, such as by walking with a dog, to working with an animal in the experimental condition (Seivert, 2014). We found that 15 studies controlled for the presence, contact, or interaction with the animal as a non-specific factor. This accounted for 8.72% of the included studies.

Environment
In this category, we included studies that controlled for environmental factors, such as being in water (e.g., Antonioli and Reveley, 2005; Hernandez-Espeso et al., 2021), being outdoors (e.g., Urban et al., 2015), or being on a farm (e.g., Breitenbach et al., 2009) in the control condition. We found that 14 studies controlled for the environment as a non-specific factor. This accounted for 8.14% of the included studies.

Interaction With Something Like an Animal
In this category, we included studies with control conditions that simulated human–animal interaction or contact with another object by, for example, grooming a plush cat (e.g., Boyer and Mundschenk, 2014) or riding a mechanical horse (e.g., Kim et al., 2016; Funakoshi et al., 2018). We found that 11 studies controlled for interaction with something like an animal as a non-specific factor. This accounted for 6.35% of the included studies.
Movement or Rhythm
All studies with conditions that controlled for movement or rhythm were included in this category. They included rhythm and music-based therapy (e.g., Bunketorp Kall et al., 2012) or the vibrations or movements of a mechanic horse (Cho, 2017; Funakoshi et al., 2018; Kim et al., 2018). We found that 5.81% \((n = 10)\) of the studies controlled for rhythm or movement as a non-specific factor.

Relaxation
In this category, we included studies with control conditions where subjects were asked to sit and relax for a certain amount of time (Fiocco and Hunse, 2017; Machová et al., 2020a,b). We found that nine studies controlled for relaxation as a non-specific factor. This accounted for 5.23% of the included studies.

Watching or Seeing Animal
Here we included studies with control conditions that exposed subjects to visual stimuli of animals, such as through videos or pictures (e.g., Hession et al., 2019; Thelwell, 2019; Vandagriff et al., 2021). We found eight studies that controlled for watching or seeing an animal as a non-specific factor. This accounted for 4.65% of the included studies.

Other
In this category, we included studies with characteristics of the control condition that did not match any other category, such as the sound of an animal (Park et al., 2019) or a proximity effect (Vandagriff et al., 2021). We found that 4.65% \((n = 8)\) of the studies controlled for other factors as non-specific factors.

Novelty
In this category, we included studies that controlled for a novelty effect by including control conditions with novel toys or plush animals (Branson et al., 2017; Germone et al., 2019; Mueller et al., 2021). We found three studies that controlled for a novelty effect as non-specific factor. This accounted for 1.74% of the included studies.

DISCUSSION
The aim of this systematic review was to present an overview of explicit factor hypotheses that researchers have presented in previous AAI studies and to identify factors that have been implicitly considered as specific factors or non-specific factors in AAI research.

Factor Hypotheses of AAI
We found that the majority of the studies (84%) mentioned a hypothesis about how AAI works. However, a substantial portion (16%) of the analyzed studies did not specify any factor hypotheses referring to concrete working mechanisms of AAI in their introductions. The most frequently mentioned factor hypothesis was that human–animal interaction leads to the effects of AAI, followed by movement by the animals, animals as social facilitators or catalysts, and the presence of an animal.
These extracted factor hypotheses all represent hypothesized working mechanisms by the authors, but most of them are not sufficiently specific for authors to avoid making assumptions about how different specific components of AAIs contribute to its effects. While human–animal interaction was mentioned by several authors as a specific factor, human–animal interaction comprises a multitude of components. For example, several studies hypothesized that human–animal interaction can reduce stress (Fiocco and Hunse, 2017; Pan et al., 2019; Machová et al., 2020b), but they did not specify how human–animal interaction leads to this possible stress-reducing effect. These rather vague factor hypotheses about human–animal interaction and AAIs reflect the current problem in the AAI research where the question of how AAIs work is still neglected (López-Cepero, 2020).

Nevertheless, our review also revealed that some studies defined factor hypotheses that are quite specific, such as the movement of the involved animals. For example, the tridimensional (Cho, 2017; Vidal Prieto et al., 2021), repetitive (Funakoshi et al., 2018; Vidal Prieto et al., 2021), and rhythmic movements of a horse (Vidal Prieto et al., 2021) have been defined as specific factors of horseback riding that are assumed to have positive effects on the humans riding the horse. But given the strong and decade-old recommendations in the literature to specify what characteristics of AAIs are important for the effects (Marino, 2012; López-Cepero, 2020), we were surprised not to find more specific factor hypotheses. We strongly suggest that authors explicitly state their hypotheses about how the presence of an animal may enhance interventions.

**Specific Factors of AAIs**

Based on the approach of component studies, which provide a method for examining the active components of a treatment, we compared the control conditions with the experimental conditions of each study. We defined a factor as specific if it was present in the experimental condition but not in the control condition. We identified that “animal” and “interaction with an animal” were the most frequent categories that previously published AAI studies have implicitly considered a specific and active component of AAIs. By using different control conditions, the studies also controlled for specific factors such as “movement by the animal,” “physical contact,” and “taking care of an animal.” For example, “movement by the animal” was controlled for by comparing horseback riding with physiotherapy (e.g., Abdel-Aziem et al., 2022), “physical contact” by comparing being interviewed while petting a dog to being interviewed without a dog (Krause-Parello and Gulick, 2015), and “taking care of an animal” by comparing participants attending lectures about healthy lifestyle choices with participants taking care of crickets (Ko et al., 2016).

The results indicate that the authors of the majority of studies implicitly considered the animal as a specific factor of the AAI. This reflects the common assumption in the AAI literature that the animal is crucial for the effects of AAIs (Marino, 2012). However, since the animal is itself a complex stimulus (Marino, 2012; Rodríguez et al., 2021) and since interaction with an animal has many different components, the animal might not be suitable as a specific factor. But the results make clear what steps are needed in AAI research. First, studies need to investigate if the animal is a specific factor and if it is needed for the effects of AAIs. And then the effects of different characteristics of animals need to be disentangled.

One characteristic of an animal that we found defined as a specific factor in several on studies equine-assisted interventions (17%) was the movement of a horse during riding. Especially in hippotherapy, research is already investigating highly specific mechanisms. If the movement of a horse is considered a specific factor in equine-assisted interventions, the question arises if this movement needs to be performed by a live horse or if it can be substituted. Similar questions are increasingly being addressed, for example, in this specific case by comparing the effects of riding on a real horse with riding on a horse stimulator (Temcharoensuk et al., 2015; Kim et al., 2016, 2018; Cho, 2017).

Although rarely mentioned, we also identified factors that were considered as specific but were independent of the animal, such as mounting material (Bravo Gonçalves Junior et al., 2020), distraction by the presence of an animal (Gee et al., 2019), frequency of the intervention (Matusiak-Wieczorek et al., 2020), familiarity with the animal (Odendaal, 2001), recreational aspects (Breitenbach et al., 2009), and therapeutic aspects (Scheidhacker et al., 2002; Breitenbach et al., 2009). This indicates that researchers are beginning to investigate and to understand what factors in AAIs can be separated from the animal.

**Non-specific Factors of AAIs**

We found that previous AAI studies have already controlled for several different non-specific factors. We considered a factor to be implicitly defined as non-specific if it was present in both the experimental and the control intervention. Most frequently, therapeutic aspects and social interactions were identified as non-specific factors. For example, some studies compared a control condition consisting of standard physiotherapy while the experimental condition consisted of standard physiotherapy with the addition of an animal (Berry et al., 2012; Machova et al., 2019; Rodrigo-Claverol et al., 2020). We thus interpreted the authors of these studies to be attempting to control for non-specific effects of the therapeutic context present in both interventions.

Some of the studies also controlled for specific elements of the interaction with the animal or the animal itself, for example, by defining the presence of an animal (Tepper et al., 2021) or simply walking with a dog (Szymanski et al., 2018) as non-specific factors. One such study had a control group with an animal present during classroom activities and an experimental group where participants interacted with an animal to complete different tasks (Tepper et al., 2021). Another study defined walking with a dog as the control intervention, while the experimental intervention had participants train dogs to be more suitable for adoption (Szymanski et al., 2018). Other examples of such specific factors of an animal were the sound of an animal (Park et al., 2019), proximity to an animal (Pendry and Vandagriff, 2019; Pendry et al., 2019; Vandagriff et al., 2021), or taking care of another living being (Colombo et al., 2006). We also found that a minority of studies defined novelty as a non-specific factor. While only Mueller et al. (2021) explicitly
mentioned having a stuffed toy present in the control group to control for the novelty effect of the animal in the intervention group, we interpreted two other studies also to be controlling for novelty when they included “novel” toys in the control condition (Branson et al., 2017; Germone et al., 2019). It has already been suggested that AAI interventions might be prone to novelty effects, which is thus a threat to construct validity (Marino, 2012), so it is rather surprising that we only identified one study that specifically controlled for novelty as a non-specific effect. This also makes clear how important it is for authors to explicitly mention their hypotheses about working mechanisms and what they considered in designing the control and the experimental conditions. Having a stuffed toy present can function as a control for different components such as feeling fur, being confronted with a novel stimulus, or receiving support.

Moreover, AAI interventions are thought to be vulnerable to placebo effects because the nature of the treatment is usually evident to the subjects (Marino, 2012). Studies on placebo effects have demonstrated that psychosocial and contextual factors related to patient perceptions of the intervention—including information about the treatment, expectations, and the treatment environment—can contribute to the overall effect of the intervention (Wager and Atlas, 2015). Moreover, research has shown that a significant part of our responses to various interventions can be explained by these contextual factors and thus by mechanisms that elicit placebo effects rather than by the specific intervention itself (Wager and Atlas, 2015). In randomized controlled trials, such contextual factors are usually controlled for with a placebo control (Colloca and Benedetti, 2005). The results from our systematic review show, however, that none of the included studies explicitly controlled for placebo effects. Dietz et al. (2012) investigated the effects of animal-assisted therapy on trauma symptoms and compared animal-assisted therapy not only to a control group but also had an intervention group that was provided narratives about the therapy dog while the other intervention group received no such narratives about the dog. Such stories might have influenced the expectations of the participants, but the authors did not mention that these conditions were intended to control for participants’ expectations as a part of a placebo effect. The lack of a control for placebo effects in previous AAI research may have led to false attributions: it might not be the animal that produces the effects of AAI interventions but rather participants’ expectations regarding the animal or a combination of both. Considering that a large part of treatment responses in other interventions such as psychotherapy or physiotherapy (Wampold, 2015; Testa and Rossettini, 2016) can be explained by contextual factors rather than by their specific factors, it seems likely that these factors also explain a large portion of the effects in AAI interventions.

**Limitations, Strengths, and Future Research**

Several studies we analyzed lacked detailed information regarding the study design and the experimental and the control conditions. Since we identified factors by looking at the study design and by comparing the control and experimental conditions, the information about the way the animal was integrated in the intervention was crucial for our results. For example, it was sometimes not clear if the animal was just present or embedded in a therapeutic narrative, what role the animal had, what amount of physical contact occurred, or even if participants rode the horses they were working with. This lack of information could have affected our categories and whether they correctly reflect the studies. For example, we might have missed specific or non-specific factors that were taken into account. We also included only English and German publications and were not able to obtain several manuscripts. Moreover, our categories reflect a subjective classification.

Finally, we only analyzed studies with active control conditions. Authors of studies without a control group might have proposed hypotheses about working mechanisms that we thus missed. A strength of this review is that we included previously published controlled studies with different types of AAIs. We thus ensured that the results are representative of different fields ranging from dog-assisted interventions to hippotherapy to educational programs including animals. In order to minimize publication bias, we also included non-peer-reviewed manuscripts, though the study quality was sometimes low. Our review presents a representative overview of the current status of hypotheses about specific and non-specific factors in AAI research based both on explicit statements by authors and on implicit measures. This is a significant step in addressing a crucial knowledge gap and provides a basis for recommendations for future research.

In future studies, authors should clearly state their hypotheses about the working mechanisms. As López-Cepero (2020) suggested, integrating an animal in human services should be justified through mechanisms that we can hypothesize and that can be verified through a scientific methodology. Similar to other treatments like psychotherapy, AAI interventions are faced with the challenge of identifying how and why AAI interventions lead to changes (Kazdin, 2007, 2009). In order to understand how AAI interventions work, identifying specific factors in AAI interventions is crucial. We propose using component studies to examine the active components of AAI interventions. This means that future studies need to carefully plan their control conditions. The results of this review provide some indications of how the familiarity of the animal (Odendaal, 2001) or the relationship to the animal (Seivert, 2014; Machova, 2019) could be considered as specific factors to be controlled for, but further specific factors should be identified. Moreover, future research should try to disentangle the specific effects by treating the animal as a complex stimulus. Authors should try to define and examine exactly what characteristics are specific to the animal and what characteristics can be substituted by a human or a non-living animal. By using robotic dogs, for example, certain confounding components such as novelty, demand characteristics, expectations, caring for someone, and physical activity can be controlled for. To design good component studies on AAI interventions, we hypothesize that future studies need more specific and innovative control interventions. We recommend that future studies not only examine more specifically which components of the animal or of the interaction with the animal may have effects but also start to acknowledge and implement knowledge from placebo research to examine the impact of contextual factors in
AAIs. We believe that this will help us better understand the mechanisms of AAIs and also determine how important the animal is for the effects of AAIs. The results of this review show that some non-specific factors such as therapeutic aspects and social interaction have already been controlled for in past studies, which suggests that the field is moving in the right direction. However, we suggest that future research pays attention to patients’ perceptions of the intervention such as information and expectations about the treatment, the treatment environment, and the therapeutic alliance. It could even be argued that the animal in AAIs may not need to be a specific factor but could rather be seen as a contextual factor. We hope to stimulate this debate in future research with this paper.

CONCLUSION

A substantial portion of previously published controlled AAI studies did not define specific hypotheses about working mechanisms. By analyzing their control conditions, we assumed that in most controlled studies, the animal or the interaction with an animal were implicitly considered a specific factor for the effects of AAIs. Non-specific factors such as therapeutic aspects, social interaction, or novelty have also been controlled for. We conclude that AAI research still cannot answer the question of how and why AAIs work. The hypotheses and results about the specific and non-specific factors in the literature on AAIs are insufficient. This poses a major knowledge gap and challenge for the future. With this paper, we have presented the first overview of what AAi research has considered as possible specific and non-specific factors. These can be used in future research to address the question of the mechanisms of AAIs. To disentangle the mechanisms of AAIs, future research should employ component studies with innovative control conditions and draw on knowledge from placebo research.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

CW and KH had the idea for the study and designed the study. CW and CG contributed to acquiring the data and carried out the analysis. CW, KH, and CG wrote the manuscript, which was revised by all authors. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.931347/full#supplementary-material

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